Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

Research Papers

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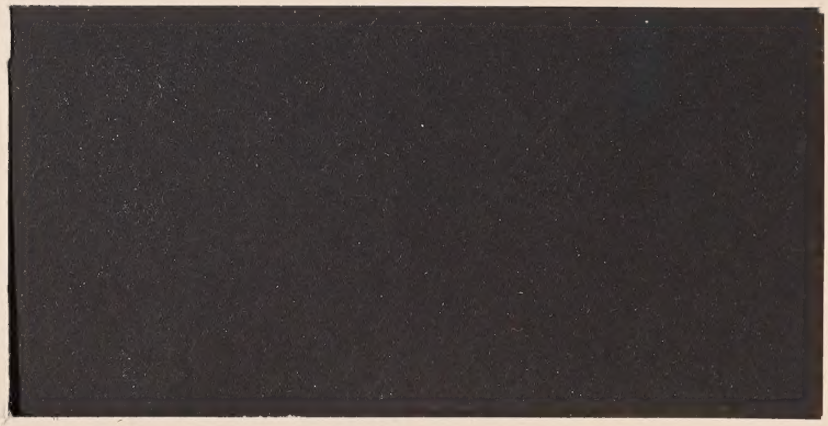
FEDERAL-PROVINCIAL CO-OPERATION IN WATER — AN EXPLORATORY EXAMINATION

by

InterGroup Consulting Economists Ltd.
Denis DePape

Canada



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Research Paper # 9

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March 1985
Winnipeg

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn

Frank Quinn
Director of Research

Abstract

This report has been prepared for the Inquiry on Federal Water Policy by InterGroup Consultants Ltd. It is one of several research studies being carried out by the Inquiry. The work was largely carried out between October and December of 1984.

The study provides an exploratory examination of water-related federal-provincial co-operation in accordance with terms of reference provided by the Inquiry. Particular emphasis is placed on identifying and discussing alternative approaches to such co-operation in the future.

Résumé

Ce rapport a été préparé pour l'Enquête sur la politique fédérale relative aux eaux par InterGroup Consultants Ltd. C'est un des projets de recherches financé par l'Enquête. Le travail a été principalement exécuté entre octobre et décembre 1984.

Cette étude fournit un examen exploratoire de la coopération fédérale-provinciale en matière hydrique tel que stipulé dans le mandat fournit par l'Enquête. L'emphase porte sur l'identification et la discussion d'alternatives pour une telle coopération dans le futur.

ACKNOWLEDGEMENTS

The consultants acknowledge the assistance of Dr. F. Quinn, Director of Research for the Inquiry. We also thank provincial and federal officials of water agencies that freely gave their time for in-person and telephone interviews.

Although the above assistance is gratefully acknowledged, InterGroup Consultants Ltd. takes responsibility for the contents of this report.

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CHAPTER 1

INTRODUCTION

A major feature of water management in Canada is the complex web of overlapping and often ambiguous federal and provincial jurisdictions. This environment is ripe for and has often been characterized by jurisdictional conflicts and intergovernmental disputes. At the same time, there is a recognition by the federal government and most provinces that real problems involving overlapping jurisdictions will only be solved through co-operation.

This situation was recognized at the federal level with enactment of The Canada Water Act in 1970. The first part of this act, which is administered by Environment Canada, focuses on federal-provincial co-operation and makes provision for various types of co-operative endeavours including joint consultative arrangements and federal-provincial agreements to plan and implement water resource programs. There has been a great deal of activity under this portion of the Canada Water Act since 1970. As well, water related federal-provincial co-operation has occurred through other federal programs. It is important for the Inquiry on Federal Water Policy to review this activity, and, on the basis of past results and emerging trends, identify possible avenues for future federal-provincial co-operation in water related areas.

The purpose of this report is to examine this topic with particular emphasis on identifying and discussing alternative possible arrangements for federal-provincial co-operation in planning and managing water resources in the medium term future. The terms of reference for this study, as provided by the Inquiry's research staff, called for three tasks to be carried out:

1. Assess the changing nature of federal-provincial co-operative undertakings in water planning and management over the past decade.

2. Review changing approaches to water resources planning and management by provincial governments that may be relevant to federal-provincial co-operative arrangements.

3. Recommend alternative arrangements for federal-provincial co-operation that would be appropriate for addressing newer water related issues and compatible with prevailing views on jurisdictional limitations.

Tasks 1 and 2 are intended to provide background perspectives for Task 3 which is the main thrust of the report. The two northern territories are not included in this study since their jurisdictional context is different and since they are the subject of a separate study by the Inquiry. Although not specified in the terms of reference, the topics of river basin planning and water issue conflict resolution were identified by the client representative as being of special interest. The study has been able to treat river basin planning quite extensively as it has been quite well documented. However, conflict resolution could not be addressed very elaborately as it is not well documented and a great deal of time and effort reviewing individual cases would have been required. To do any justice to this topic would require a separate study which would include not only the Canadian, but also the more extensive American experience.

The study was carried out using readily available documentation and a limited number of in-person and telephone interviews. Time and budget limitations precluded primary data gathering and an elaborate interview program. The primary sources of information used were:

1. Canada Water Act Annual Reports -- These reports review in considerable detail activities that occurred in the previous year under The Canada Water Act. Included is a listing and description of all federal-provincial programs that were active in that year and completed in previous years. An assessment was made of active programs in 1975-76, 1981-82 and programs completed during the years 1971-75, 1976-80, 1981-84, to identify major trends in federal-provincial programs under the Act. Tables and observations from this assessment are presented at the end of this chapter and are referred to throughout this study.

Some special information is included in the tables to provide a fuller appreciation of their contents:

a. Most of the programs identified in the tables are covered by federal-provincial agreements. Exceptions occur, however, with some pre-planning activities which take place without an agreement; these are noted in the tables.

b. In a number of cases federal-provincial agreements initiated prior to enactment of The Canada Water Act in 1970 were continued under the Act; these are included in the tables and then pre-1970 start-up status noted.

c. Environment Canada is the lead agency for activities under The Canada Water Act. However, in many cases, other federal departments have also participated in Canada Water Act agreements. This includes Agriculture Canada, the Department of Regional Industrial Expansion (DRIE) and its predecessor the Department of Regional Economic Expansion (DREE), Fisheries and Oceans (FAO), National Health and Welfare (NHW), Central Mortgage and Housing Corporation (CMHC), the Ministry of Transport (MOT), the Department of Indian Affairs and Northern Development (DIAND), and the Department of Public Works (DPW). The tables note where these other departments were involved.

2. Interviews with Senior Provincial Officials -- Lengthy in-person or pre-arranged telephone interviews were conducted with senior water officials in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia and Prince Edward Island. Three major areas were addressed in the interviews: (a) interesting and innovative organization, planning and management approaches to water being used or contemplated by the province; (b) their views on water related federal-provincial co-operation since enactment of The Canada Water Act; (c) their suggestions on what arrangements might be adopted to enhance federal-provincial co-operation in the future. These interviews produced many useful perspectives that

are noted specifically or reflected in this report. While not all provinces were interviewed, those that were provide a good cross-section of views and experience on the topics covered in the interviews. Some officials were reluctant to be quoted or specifically identified in the report. For this reason, the province(s) that made certain suggestions are often not identified in the text, even though such information would be useful.

3. Submissions to the Inquiry -- Submissions made to the Inquiry that addressed or referred to the area of federal co-operation were reviewed. These include submissions made by the provinces, by federal agencies and by some individuals and interest groups. In total, fifteen submissions were reviewed. These submissions provided many useful details and perspectives on the experience to date with federal-provincial co-operation and some ideas on where alternative or additional arrangements might be relevant in the future. They were especially relevant in providing an understanding of the views of federal agencies toward these topics.

4. Review of Key Relevant Studies and Articles -- A number of relevant articles and studies were reviewed. Particularly well documented and useful were the following recent items on river basin planning:

   (a) Environment Canada Evaluation Team. An Evaluation of the Planning and Implementation Programs. Ottawa, Ontario, November, 1981.

   (b) B. Mitchell and S.S. Gardner (eds). River Basin Management: Canadian Experiences. University of Waterloo, 1983.

The results of our information gathering indicate that there has been a great deal of federal-provincial co-operation in water related areas since 1970. This can be broken down into several categories and sub-categories which we have used to organize the remaining sections of this report.

1. Federal-Provincial Agreements -- This is the major area of activity. Since 1970, about 60 federal-provincial programs have been carried out under The Canada Water Act for planning and implementation of water programs, water regulation and data collection and the Flood Damage Reduction Program. Of these, about 55 have been federal-provincial agreements; the remainder have been pre-planning studies without agreements. Five of the agreements were initiated prior to 1970 but continued under The Canada Water Act. As shown in Table 1, there were between 26 and 38 active agreements in the three years that we examined

and 24 agreements had been completed by 1983. There have been agreements in all provinces under The Canada Water Act.

TABLE 1

CATEGORIES OF ACTIVE AND COMPLETED FEDERAL-PROVINCIAL AGREEMENTS UNDER THE CANADA WATER ACT IN SELECTED YEARS

Category of Program	Active[1/] During the Year. 1975-1976	1980-1981	1983-1984	Completed in Previous Years 1971-1975	1976-1980	1981-1983
PLANNING AND IMPLEMENTATION						
- Planning Studies	8	5	6	5	7	2
- Implementation Agreements	6	5	4	0	4	1
	14	10	10	5	11	3
REGULATION & DATA COLLECTION						
- Regulation and Apportionment	1	2	2	-	-	1
- Inventories, Surveys and Monitoring	10	13	13	1	-	1
	11	15	15	1	-	2
FLOOD DAMAGE REDUCTION PROGRAM						
- Project Specific	0	2	5	-	1	1
- Province-Wide	1	6	8	-	-	-
	1	8	13	-	1	1
Total	26	33	38	6	12	6

[1/] Excludes projects under negotiation.

Table 2 shows the provincial distribution of agreements in 1975-76, 1980-81 and 1983-84. In each of these years, nearly all provinces had two or more agreements, while British Columbia, Saskatchewan, Manitoba, Ontario and, in the last two of the years, Quebec, have had five or more active agreements. This is an impressive amount and composition of activity and indicates an obvious interest in such programs and agreements by both the federal and provincial governments. In looking at possible alternative arrangements for the future, the significant degree of co-operation that has been achieved to date with the prevailing agreement structure must be heeded. Change for the sake of change, or for some apparent emerging trend, should be pursued with great caution. Most agreements involve sharing of costs and resources by the federal and provincial governments. The federal government, usually through Environment

Canada, provides work and expertise as well as funding. Exceptions occur in certain agreements with Quebec where the federal government provides only funding. The provincial government does all of the work and provides all of the funding. Agreement management structures vary considerably.

TABLE 2

PROVINCIAL GOVERNMENT PARTICIPATION IN AGREEMENTS UNDER THE CANADA WATER ACT

Province	Number of Active Programs in		
	1975-76	1980-81	1983-84
British Columbia	4	6	6
Alberta	2	3	2
Saskatchewan	6	6	5
Manitoba	4	8	8
Ontario	6	7	5
Quebec	3	6	9
New Brunswick	2	4	2
Nova Scotia	2	3	2
Prince Edward Island	1	1	2
Newfoundland	2	2	3

In addition to these agreements sponsored by Environment Canada under The Canada Water Act, there have also been numerous water related federal-provincial agreements sponsored by other federal departments, in particular, the Department of Regional Industrial Expansion (DRIE) and its predecessor, the Department of Regional Economic Expansion (DREE). We did not determine the number of these agreements, however, there were at least fifteen.

These federal-provincial agreements can be broken down into two broad categories according to their geographic sphere:

(a) Basin or water body oriented agreements -- These agreements pertain to a specific river basin, sub-basin, portion of basin, or water body, and are usually identified by that basin or water body. All agreements in this category were sponsored by Environment Canada. Within this category there are two relevant sub-categories:

(i) Comprehensive River Basin Planning and Implementation Agreement -- In the context of The Canada Water

Act, this is an area in which the federal government undertook a leadership role trying to encourage the provinces to participate in such studies. As a result, it has been a topic of special interest in considering the experience to date under The Canada Water Act. Notable features of the comprehensive basin planning approach were the emphasis on looking at the whole river basin and at multiple water related issues within the basin. Agreements in this category are presented in Table 3.

(ii) Specific Issue Oriented Agreements -- Agreements in this category are much more focused than comprehensive basin agreements. They can pertain to less than a full river basin and to one, or a few, water related issues in the area being considered. Many of the agreements in this area have been developed in response to immediate requirements to resolve a water conflict and to specific requests from the provinces. Tables 4, 5, 6, 7 and 8 present agreements in this category according to five classes of issues.

(b) Province-wide agreements -- These agreements address particular water related issues on a province-wide rather than basin or water body basis. This category includes agreements sponsored by Environment Canada and by other federal departments. As shown in Table 9, those sponsored by Environment Canada consist of the Flood Damage Reduction Program and the water quantity surveys. In the Prairie Provinces, in particular, where the Prairie Farm Rehabilitation Program (PFRA) is active, agreements sponsored by other agencies are a major aspect of federal-provincial water related activities.

2. Non-Agreement Activities -- This is a much less conspicuous, and often quite informal, area of federal-provincial activities. Relatively little, except in regard to pre-planning studies, was discovered about this area in this study although it was considered important to most of the provincial officials that we interviewed. The main thrusts appear to be information exchange and joint work sharing projects that are not appropriate for an agreement (e.g., pre-planning studies; technical workshops on benefit-cost analysis, water modelling, etc., exchange of technical advice).

While conducting this study, a number of items emerged that have or could have an overriding influence on federal-provincial co-

operation in the water area. These are major elements of the environment in which co-operation occurs and therefore must be kept in mind in discussing any possible future arrangements for federal-provincial co-operation.

1. Provincial Attitude to Federal Intrusion -- There are differing attitudes among provinces about getting involved with the federal government on joint projects. This attitude usually is not unique to water projects but rather applies to federal-provincial projects in general. A spectrum exists from provinces that are highly protective of their jurisdictions and will only participate in federal-provincial activities where it is essential, to provinces that, while concerned about maintaining their jurisdictions, are generally quite interested in participating in joint programs. The opportunity to obtain federal funds is often a key motivating factor in the last group. Interestingly, the extreme ends of the spectrum are represented by prairie provinces. Alberta has consistently been very reluctant to enter into federal-provincial agreements, while Manitoba and Saskatchewan have consistently sought out such agreements. The remaining provinces have generally been in between.

   Provinces have sometimes shifted their outlook to water related federal-provincial co-operative activity as governments or circumstances have changed. A notable example of particular relevance to water is British Columbia. One of the principal participants in water related federal-provincial agreements since 1970, this province has recently become significantly less willing to participate in further agreements.

   The presence of these differing attitudes means that it will always be difficult to get all provinces involved in various federal-provincial activities. This is particularly true in areas where the federal government wants to provide leadership. For this reason, arrangements for federal-provincial co-operation must be flexible and capable of addressing provincial, as well as federal, interests. This probably means that a variety, rather than one type, of arrangement is needed. The approach to date recognizes this by having diversity of agreement and non-agreement arrangements.

2. Government Fiscal Restraint -- An increasingly prevalent and prominent feature of the federal and provincial government scene is fiscal restraint and even cutbacks. This is in sharp contrast to the early and mid-1970s when governments were expanding rapidly. This feature has already affected water related activities in most provinces and federal government. It will likely become more severe in the future. If it does,

> there will be fewer federal resources available in real terms for federal-provincial co-operative activities in the water area. This will make co-operation more difficult as it likely will mean that federal water agencies will have to take a more restricted view of what is in the national interest when deciding projects to undertake. The corollary to this is that the degree of admissible provincial interest in proposed activities will be diminished.
>
> At the same time, from the provincial standpoint, various responses to their internal fiscal constraints can occur that will be relevant for federal-provincial co-operation. Some provinces will retrench their involvement in joint activities arguing that, while such activities provide access to federal dollars, they more importantly impose demands on provincial resources. This appears to be the approach adopted recently by British Columbia in conjunction with government cutback programs that they introduced. At the other extreme, provinces will try harder to get federal involvement and resources to help offset the effects of provincial cutbacks.
>
> These and other possible responses to fiscal restraints and cutbacks are likely to be an integral part of the environment for federal-provincial co-operation in the near or medium term future. They are likely to produce a more strained environment for federal-provincial co-operation at least in the short term. In the long term, the situation might improve as it becomes apparent that sharing and co-operation become inceasingly relevant as available resources decline. Future federal-provincial arrangements should be capable of adapting to changes in the general level of co-operativeness.

Most of the remainder of this report examines experience to date and identifies alternative possible arrangements for federal-provincial co-operation according to the previously noted categories of activity. Chapters 2, 3 and 4 address federal-provincial agreements with Chapter 2 covering comprehensive river basin planning and implementation, Chapter 3 specific issue oriented agreements, and Chapter 4 province-wide agreements. Chapter 5 is concerned with non-agreement activities, while Chapter 6 presents some concluding perspectives.

TABLE 3

ACTIVE AND COMPLETED FEDERAL-PROVINCIAL PROGRAMS UNDER THE CANADA WATER ACT
COMPREHENSIVE RIVER BASIN PLANNING AND IMPLEMENTATION

Active	1975-76	1980-81	1983-84
pre-planning (no agreements)	-Lower Saskatchewan River	-Thompson River	
planning	-Shubenacadie-Stewiacke -Souris	-Shubenacadie-Stewiacke	
implementation	-Okanagan basin (also CMHC) -Qu'Appelle basin (also DREE, DIAND, CMHC)	-Okanagan basin -Qu'Appelle basin -Souris*	-Qu'Appelle -Souris*

Completed	1971-75	1976-80	1981-83
pre-planning (no agreements)	-Saskatchewan-Nelson basin (1973) (pre-1970 start-up)	-Lower Saskatchewan River (1979)	-Thompson River (1981)
planning	-Qu'Appelle (1972) -Okanagan (1974) -Saint John (1975)	-Souris (1978)	-Shubenacadie-Stewiacke (1982)
implementation			-Okanagan (1982)

* Recommendations dealing with floods and water supply are being implemented within The Canada-Manitoba Flood Damage Reduction Agreement and The Canada-Saskatchewan Subsidiary Agreement (DREE).

TABLE 4

ACTIVE AND COMPLETED FEDERAL-PROVINCIAL PROGRAMS UNDER THE CANADA WATER ACT
FRAMEWORK AND SPECIFIC ISSUE BASIN PLANNING

Active	1975-76	1980-81	1983-84
pre-planning (no agreement)	-Mackenzie River Basin Committee (also DIAND, MOT)	-Winter River (reliability of water supply system)	
planning -framework study		-Mackenzie River Basin Study (also DIAND, MOT)	-Yukon River (also DIAND)
-specific issue study		-Fraser River Estuary (estuary planning)(also FAO)	-Fraser River Estuary
		-Waterford River (urbanization effects)	-Waterford River -Winter River
implementation planning			-Mackenzie River Basin Committee (also DIAND, MOT)
Completed	**1971-75**	**1976-80**	**1981-83**
pre-planning (no agreements)		-Yukon River (1979)	-Winter River (1983)
planning -framework study			-Mackenzie River Basin Study (1982)

TABLE 5

ACTIVE AND COMPLETED FEDERAL-PROVINCIAL PROGRAMS UNDER THE CANADA WATER ACT
FLOOD PROTECTION AND FLOW REGULATION

Active	1975-76	1980-81	1983-84
planning	-Flow Regulation - Montreal region -Fraser River Upstream Storage		
implementation	-Lower Fraser Valley Flood Control -Southwestern Ontario Dyking (also Agriculture)	-Lower Fraser Valley Flood Control -Flood Proofing - Red River Valley	-Lower Fraser Valley Flood Control
Flood Damage Reduction Program (since 1976)		-Flood Management - Marsh Creek, B.C. -Dykes and Flow Regulation - Montreal region	-Flood Management - Marsh Creek, B.C.; Dykes and Flow Regulation - Montreal region; Upgrading Dykes - Red River Valley; Mille Iles Flood Control Structure - Montreal Region; Quebec City Flood Control
Completed	**1971-75**	**1976-80**	**1981-83**
planning		-Flow Regulation - Montreal region (1976) -Fraser River Upstream Storage (1976)	-Flood Proofing - Red River Valley (1981)
implementation		-Southwestern Ontario Dyking (1979)	
Flood Damage Reduction Program		-Southeastern New Brunswick Dyking (1978)	-Dykes and Flow Regulation - Montreal region (1981)

TABLE 6

ACTIVE AND COMPLETED FEDERAL-PROVINCIAL PROGRAMS UNDER THE CANADA WATER ACT
WATER QUALITY ASSESSMENT OR MANAGEMENT

Active	1975-76	1980-81	1983-84
planning	-St. Lawrence River -Lower Great Lakes	-Lake Winnipeg	
implementation		-Great Lakes	-Great Lakes
inventory, monitoring and surveys			-Ottawa River Co-ordinating Committee
Completed	**1971-75**	**1976-80**	**1981-83**
planning		-St. Lawrence River (1978)	-Lake Winnipeg (deferred)

TABLE 7

ACTIVE AND COMPLETED FEDERAL-PROVINCIAL PROGRAMS UNDER THE CANADA WATER ACT
MAJOR PROJECT IMPACT ASSESSMENT/MITIGATION

Active	1975-76	1980-81	1983-84
planning	-Churchill River		-English-Wabigoon Mercury Contamination (also FAO,NHW)
implementation	-Peace Athabasca Delta		-Churchill River Diversion Mercury
inventory, monitoring and surveys		-Garrison Diversion Water Quality Monitoring -St. Lawrence North Shore Ecological Inventory	-Garrison Diversion Water Quality Monitoring(also FAO) -St. Lawrence North Shore Ecological Inventory

Completed	1971-75	1976-80	1981-83
planning	-Peace Athabasca Delta (1972) -Lake Winnipeg, Churchill and Nelson Rivers (1975)		
implementation		-Peace Athabasca Delta (1976)	

TABLE 8

ACTIVE AND COMPLETED FEDERAL-PROVINCIAL PROGRAMS UNDER THE CANADA WATER ACT
OTHER SPECIFIC ISSUE ORIENTED AGREEMENTS

Active	1975-76	1980-81	1983-84
implementation - Canada Water Conservation Assistance Act Agreements	-Metropolitan Toronto (pre-1970 start-up) -Upper Thames (pre-1970 start-up)		
regulation and apportionment	-Prairie Provinces Water Board	-Prairie Provinces Water Board -Ottawa River Regulation Planning Committee (also DPW)	-Prairie Provinces Water Board -Ottawa River Regulation Planning Board
other	-Northern Ontario Water Resources (pre-1970 start-up)		

Completed	1971-75	1976-80	1981-83
planning		-Northern Ontario Water Resources (1978) (pre-1970 start-up)	
implementation - Canada Water Conservation Assistance Act Agreements		-Metropolitan Toronto (1978)(pre-1970 start-up) -Upper Thames (1979) (pre-1970 start-up)	
regulation and apportionment			-Ottawa River Regulation Planning Committee
inventories, surveys and monitoring	-Great Lakes Shore Damage Survey (1975)		-Great Lakes Shore Damage Survey implementation (1981)

TABLE 9

ACTIVE AND COMPLETED FEDERAL-PROVINCIAL PROGRAMS UNDER THE CANADA WATER ACT

PROVINCE-WIDE PROGRAMS

Active	1975-76	1980-81	1983-84
Flood Damage Reduction Program (since 1976)	-Agreement with New Brunswick	-Agreements with New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan and Northwest Territories	-Agreements with Newfoundland, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan and Northwest Territories
Continuing Surveys	-Water Quantity Surveys -- all provinces (pre-1970 start-up)	-Water Quantity Surveys -- all provinces (pre-1970 start-up)	-Water Quantity surveys -- all provinces (pre-1970 start-up)
Completed	**1971-75**	**1976-80**	**1981-83**
all programs are still active			

CHAPTER 2

COMPREHENSIVE BASIN PLANNING AND IMPLEMENTATION AGREEMENTS

The Canada Water Act of 1970 enabled the federal government to enter into agreements with the provinces for water related planning and implementation projects. The Act stated that:

> "... with respect to any waters where there is a significant national interest in the water resource management thereof, from time to time to enter into agreements with one or more provincial governments to ...
>
> (d) formulate comprehensive water resource management plans .. based upon an examination of the full range of reasonable alternatives and taking into account views expressed at public hearings and otherwise by persons likely to be affected by implementation of the plans;
>
> (e) design projects for the efficient conservation, development and utilization of those waters; and
>
> (f) implement any plans or projects referred to in paragraphs (d) and (e), and establishing or naming joint commissions, boards or other bodies empowered to direct, supervise and co-ordinate such programs."

While not stated specifically in the Act, it was expected at the time of enactment that comprehensive river basin planning studies and their subsequent implementation would be the center piece for federal-provincial co-operation in this area. Other, more issue specific, federal-provincial planning and implementation projects were expected to emerge, but comprehensive river basin planning and implementation was the area in which the federal government would focus its leadership and encourage provincial involvement.

Federal interest and leadership in this area arose from initiatives that began in 1967 when the federal minister responsible for co-ordinating water programs invited some provincial counterparts to finance jointly a pilot project in river basin planning in each of the major regions of Canada, i.e., the Atlantic, Quebec, Ontario, the Prairie Provinces

and British Columbia. During the initial years after the Act came into effect, this continued to be the main thrust of federal involvement and leadership in federal-provincial planning and implementation. In the Federal Policy Statement on Inland Waters issued in 1978, the Cabinet reaffirmed the significance of joint basin planning and also noted the relationship between planning and implementation in the following statements:

4. Joint, cost-shared federal-provincial comprehensive river basin studies are recognized as the primary means of planning for multi-purpose water use, and public participation is considered to be an integral and vital part of such studies.

5. The federal government will not provide funds for the implementation of water programs unless it has first participated in the planning of these programs or has satisfied itself that the national aspects have been given full consideration.

The status of federal-provincial comprehensive basin planning and implementation program is depicted in Table 3. Several key observations emerge from this table. These, supplemented by perspectives drawn from other relevant information sources reviewed during the study, are as follows:

1. Since 1971, five joint comprehensive basin planning studies have been completed, i.e., Qu'Appelle, Okanagan, Saint John, Souris and Shubenacadie-Stewiacke. Implementation has, or is, occurring in most of these plans, however, only the Qu'Appelle and Okanagan have in place federal-provincial agreements under The Canada Water Act for plan implementation. Plans in the remaining basins are being implemented under specific issue agreements with Environment Canada (e.g., the Flood Damage Reduction Program), under federal-provincial agreements involving other federal government agencies (i.e., DREE or DRIE) or exclusively by the province involved. The variety of implementation approaches is indicative of the varying degrees of acceptance of the basin plans by the governments involved and the diversity of agencies that have a role in implementing water programs. There have also been three pre-planning studies that have not yet led to detailed comprehensive planning under the Act, i.e., Lower Saskatchewan River, Thompson River, Winter River. However, the Province of Alberta is carrying out a comprehensive planning study on the portion of the South Saskatchewan River basin in Alberta, while Saskatchewan is consider-

ing undertaking a similar study with federal assistance for the Saskatchewan portion of the same basin. As such, some detailed planning is occurring or emerging relative to one of the above pre-planning studies. Although not shown, each of the five planning studies also had a pre-planning stage.

2. There has been a significant decline in joint river basin planning from the first five years of the agreement, i.e., 1971 to 1975 to subsequent years. During the first five years, all five planning studies were active at some time and three were completed. During the next five years, two planning studies were active and one was completed. Between 1981 and 1983, one planning study was active and subsequently completed. No comprehensive planning studies are occurring at present. This trend of declining activity in joint basin planning has been attributed to a number of factors, most of which have been identified in an Environment Canada evaluation of joint river basin planning and implementation programs. These factors are:

   (a) Fiscal restraint by the federal government, which started to become significant in the late 1970s. River basin planning was expensive in itself, but also carried with it the potential for much greater expenditures if the plans were implemented. Also, such planning is highly anticipatory rather than reactive in nature. It is generally more difficult to get political support for such activities.

   (b) There were problems with the planning process which discouraged participants in particular provincial governments and some involved publics. These problems which have been described and summarized in a number of sources, i.e., the aforementioned evaluation (1981), O'Riordan (1981) and Mitchell (1983), included the following:

      (i) studies took too long to complete;
      (ii) much of the work was of limited relevance; a focus on addressing pressing and major issues was lacking. As a result, the product was overly costly;
      (iii) recommendations were often too numerous, ambiguous and abstract to help the implementing agencies. This also made them difficult to implement;
      (iv) the transition from planning to implementation was slow and lacked co-ordination;
      (v) operating in the federal-provincial agreement environment was administratively cumbersome.

(c) Planning that in the early 1970s would have fallen under the purview of comprehensive basin planning was being picked up in a piecemeal way by other projects or programs. This included issue specific federal-provincial agreements under The Canada Water Act, the Flood Damage Reduction Program under The Canada Water Act, Canada-U.S. agreements dealing with water and federal-provincial agreements with DREE dealing with water resource development.

(d) A shift in interest occurred with respect to federal-provincial agreements under The Canada Water Act from the comprehensive basin approach to addressing specific issues. This, in part, was an outgrowth of the dissatisfaction with the comprehensive basin planning approach noted in item (b) above. It also reflects an increased willingness on the part of the federal government to support planning projects requested by provincial governments.

3. The joint planning basin studies cover three of the five regions of the country that they were originally intended to reach. Two plans were developed in the Prairie Provinces and in the Atlantic, one in British Columbia and none in Ontario and Quebec. The latter two provinces declined an invitation to participate in a comprehensive basin planning study of the Ottawa River. In the late 1970s and early 1980s these provinces entered into two issue specific federal-provincial studies pertaining to the Ottawa River, one on water quality and another on flow regulation.

The impression that one gets from reviewing the federal-provincial experience on basin planning is that comprehensive river basin planning and implementation is on the way out. It was an idea for the late 1960s and 1970s but not the 1980s. There are simply too many problems, insufficient resources and not enough interest in this area to sustain it in the future. As well, many of the functions handled by comprehensive basin planning are being undertaken in other ways. Although not stated directly, this view seems to be reflected in the following suggestions made at the end of the Environment Canada evaluation:

> "we feel that when existing commitments terminate it may be more appropriate that any further basin related work be undertaken in conjunction with other water programs as follows:

1. River Basin Planning and Basin Planning Implementation and Interprovincial Programs be merged into a program concerned with Federal-Provincial-Territorial waters; and

2. Canada-U.S. transboundary related projects/issues be addressed under a 'Canada-U.S. Program'."

Adopting this suggestion would likely ensure that real and implicit federal leadership in the area of comprehensive river basin planning would be greatly downplayed.

Although comprehensive basin planning and implementation appears to be waning as an area of federal leadership and federal-provincial involvement, there remains a great deal of interest in many of the provinces in basin planning and management. Many provinces, particularly in the western part of the country, have organized some or all of their water resource administration and activities around watersheds and river basins. In these provinces, watershed or basin planning projects are being carried out or contemplated.

The experience with basin planning carried out under The Canada Water Act, as well as the more recent and ongoing provincially led developments provide certain insights and perspectives for shaping a continuing federal presence in this general area. During the conduct of this study, partially as a result of interviews with provincial officials and partially as a result of a review of available documentation, a number of pertinent situations and developments have been identified. These are discussed as follows:[1/]

[1/] This may not be complete since our interviews did not include all of the provinces.

British Columbia -- In the early 1980s, the Province of British Columbia initialed a strategic planning approach to establish management policies, priorities, and plans at the provincial, regional, basin and sub-basin level for water and other environmental resources, i.e., fish, marine resources, wildlife, air quality. The essence of this process involves a series of environmental resource or basin plans to be prepared for 40 planning units in the province. The area of these planning units is based on river basins or portions of the provinces, larger river basins or combinations of smaller watersheds. The results of the basin plans would be integrated upward to formulate regional and provincial policies. They would also act as the basis for sub-basin operational planning and specific resource management actions. In addition, they would be used laterally in the development of integrated multiple resource management plans. The process of developing the plans sought to avoid some of the problems encountered in the comprehensive river basin studies, while at the same time, making use of positive features. To speed up the initial planning process, only existing data and information were used. Any needed improvements in data were built into the plan. To maximize the prospects for plan implementation, there was extensive consultation during the planning process with departmental officials that would be responsible for implementation. As well, the strategic planning approach was built right into the departmental budget. Recommendations from the plans were costed and inserted into the following years' budget estimates.

The original intent was to complete 6 to 8 plans per year until all the plans were done. Some of the plans have been completed, however, the planning process has been significantly retarded by the British Columbia government's major fiscal restraint program introduced in 1983. There has been a shift in emphasis away from planning in general towards a more reactive approach to water management. Development of a provincial and regional computerized management information system has become a priority. Hardly any time is now devoted to preparing basin plans. The little that is done occurs on those basins where significant, pressing problems exist.

Ontario -- Water resource management is divided between two ministries:

(a) Ministry of Environment -- responsible for water quality oriented matters;

(b) Ministry of Natural Resources -- responsible for water quantity oriented matters; also oversees the Conservation Authorities discussed further below.

These agencies have supported several major basin planning initiatives in the Toronto area. Depending on the experience with these, additional major planning studies may be carried out in other locations in Ontario. Basin planning is regarded as an important area of future activity by the Ministry of Environment. The Ministry would like to devote considerably more attention to this area in the future than it has in the past few years.

A key element in water and other resource management in Ontario are 39 Conservation Authorities, some of which have been in existence for more than 35 years. These Authorities are designed to enable municipal management of some aspects of natural resource activity within the Conservation Areas. Their boundaries are linked to watersheds with some adjustment for municipal boundaries. Watershed and basin overlaps do occur and this has led to a number of inter-authority management exercises.

In 1979, the provincial government directed each Conservation Authority to prepare a watershed plan. Such plans were deemed necessary to enable the Conservation Authorities to function more effectively as there had been considerable concern about the inadequacies of the Authorities in fulfilling their mandates. There has been considerable progress in the development of the watershed plans to date.

Manitoba -- In the mid-1970s, Manitoba moved into establishing Soil and Water Conservation Districts to devolve some soil and water management functions to the municipalities. So far, five moderately sized Districts have been formed and special efforts are being contemplated to encourage the formation of more of these. While the boundaries of the Districts correspond to the municipal boundaries of the included municipalities, an effort is made in the formation of the Districts to include municipalities that comprise particular watersheds or river basins. Once a District is formed, they are supposed to develop a resource management plan that will provide a basis for their actions and programs. There have been difficulties in getting these plans, which are similar to watershed plans, developed. An approach centered around overlay mapping appears to be gaining acceptance.

Alberta -- Alberta did not participate in any of the federal-provincial basin planning studies due to a general reluctance to participate in any water related federal-provincial agreement. In spite of this, Alberta has been a leader in Canada in river basin planning and management since the mid-1970s. The province has been divided into six river basin planning

areas and a basin planner has been assigned to each. Broadly oriented basin plans have either been developed, or are in the process of being developed, for each basin. In each case, the planning exercises have included substantial public participation programs. While basin planning is well established in the province, it is regarded as secondary to land use planning. There is no legal requirement to produce and implement river basin plans whereas there is such a requirement for land use plans.

As part of this planning exercise, Alberta recently completed one of the most ambitious and elaborate basin planning projects ever undertaken in Canada. This is the South Saskatchewan Basin Planning Project. This study, which pertains to three interrelated tributaries that flow into the South Saskatchewan River, seeks to develop a strategy for basin management before getting into the details of program and project determination and design. It focuses on developing responses to three questions about water use priorities, water management priorities and the degree of utilization of the three tributaries given the Prairie Provinces Master Agreement on Apportionment. Public hearings were held in fall 1984 by the Alberta Water Resources Commission, in directly affected communities. The study will be shepherded through the provincial government decision making process by the Alberta Water Resources Commission which has the mandate to co-ordinate and advise the Cabinet on water related questions in the province.

Saskatchewan -- In mid 1984, this province consolidated all of its water related activities, except for water quality, into one organization, the Saskatchewan Water Corporation. While such a consolidation is not new (e.g., the Water Resources Branch in Manitoba has nearly the same scope of functions as the Saskatchewan Water Corporation), inclusion of water activities into a Crown corporation is unprecedented. The Corporation has divided the province into six regions that reflect the boundaries of all or a portion of the major river basins in the province. Regional offices and advisory committees have been established in each region.

A principal activity that the Corporation is in a hurry to get under way is development of basin plans for the six basins in the southern and central parts of the province. The intent is to complete the plans quickly so they may be used in operational planning and in making day-to-day water management decisions. Extensive involvement of regional staff and advisory groups is contemplated to ensure their commitment to the plans. For example, these groups would have a major say in the priority issues to be addressed in the planning process.

The Water Corporation would like to have federal assistance in undertaking all of these plans since the Corporation does not have the financial resources to do this on their own over a reasonable span of time.

Requests for assistance have been initiated with Environment Canada. Corporation officials express some concern that the federal pre-planning process is overly time consuming and unnecessary and will hamper timely delivery of the plans. Also, the need to satisfy the national interest requirement may preclude federal involvement in some plans.

Nova Scotia -- This province does not have a formal basin planning program, however, the need for such a program is clearly recognized. Nova Scotia's brief to the Inquiry states:

"The tendency to develop policies in response to specific water problems or during the assessment of an industrial undertaking has detracted from management of water on a comprehensive watershed or regional basis. Most water related activities have an impact on downstream users. A geographical unit, such as a watershed, provides an effective basis for considering the environmental and economic effects of allocating water supplies and water quality to specific users. Therefore, both levels of government should commit themselves to planning inter-jurisdictional water policy priorities on a watershed basis."

Prince Edward Island -- This province is becoming more involved in basin planning. All water planning is done on a watershed basis and increasingly this planning is moving from single issue to multiple issue/multiple use planning. Work is under way on a planning project that will consider various uses and user groups, including agricultural, municipal and commercial interests, in one of the province's watersheds.

The review of activities and developments in many of the provinces indicates a significant and possibly growing interest in basin planning at the provincial level. It is probably no coincidence that provincial initiatives in basin planning began to emerge in the mid-1970s after the main portion of the work on the federal-provincial basin planning studies had been completed. Undoubtedly, federal leadership in this area had an important impact on the provinces' behaviour. While there is likely little need for formally renewing federal leadership in

this area, there does appear to be a continuing need for the federal government to be able to participate in joint basin planning studies. This is apparent in the recent requests from Saskatchewan. Also the British Columbia experience suggests that as provincial government fiscal constraint programs occur, basin planning activities initiated by the province can suffer dramatically. If there was federal involvement in these activities, the adverse effects might noticeably be dampened.

This review of developments suggests that there could be several approaches that the federal government could adopt towards future participation in basin planning studies:

1. React on a case-by-case basis -- The federal government could be prepared to consider provincially initiated requests to conduct a joint basin planning study. Any such request would be assessed like any other request for water related planning or development assistance. Leadership for actually conducting the studies would be shifted from the federal to the provincial governments, but the opportunity would remain to carry out such studies on a joint federal-provincial basis. Each request would be assessed on its own merits relative to its contribution to the "national interest" and its priority to compete for available federal resources. With declining federal leadership in the area of comprehensive basin planning, this approach has in large part been adopted by the federal government. As such, choosing this approach for the future would represent a continuation of the status quo as it has emerged since the mid- to late 1970s.

2. Province-wide program -- This would be a more ambitious approach, which in many respects would be the basin planning equivalent of the Flood Damage Reduction Program. Instead of negotiating separate agreements for each basin study, an envelope agreement would be signed with interested provinces to carry out a series of basin planning studies within that province's jurisdiction. The agreement would set out certain principles about basin planning and management and about the planning process that both parties agree to, as well as a program for conducting the basin studies. Any major implementation expenditure obligations for the federal government arising from the plans would be subject to separate sub-agreements.

This approach could be adopted as an example of federal leadership, wherein the federal government would try to establish agreements with most of the provinces. The program would represent a way of encouraging the provinces to make greater use of a basin approach to water resource management and to conduct basin planning studies in many or most parts of the province. Most likely, however, it would be preferable to refrain from this leadership model given some of the difficulties experienced with the individual joint basin planning studies. Instead, the provinces could be given the responsibility for initiating requests for such agreements, after being informed that the federal government would be prepared to entertain such requests. This approach would create the opportunity for many more joint basin studies to be carried out than would the case-by-case approach.

Many studies that would be excluded on "national interest" grounds in a case-by-case approach could be included under a province-wide agreement. Of course, it would have to be decided before establishing this program whether having provinces engage in basin planning and management is itself in the "national interest".

There is a good chance that this program would be well received by some provinces. Saskatchewan appears to have an immediate interest and requirement for such an approach. With their growing interest in watershed and basin planning, Manitoba and Ontario would also likely be attracted to this approach. On the other hand, such provinces as British Columbia and Alberta who are very sensitive to any expansion of federal involvement, likely would not take up this type of program even though they are quite involved in basin planning.

3. Combination of 1 and 2 above -- It is possible also to envisage an approach in which both province-wide and case-by-case agreements could be considered. Province-wide agreements would be limited to carrying out smaller, less time consuming and costly studies, e.g., the type of basin studies carried out in British Columbia using only secondary sources. Case-by-case agreements would be used for the larger, more costly studies, e.g., those requiring significant primary data collection.

Regardless of the approach adopted for joint federal-provincial involvement in basin planning, it is important that the lessons learned from the earlier joint basin planning exercises be taken into account in establishing the study framework. It would seem appropriate for the

federal government to insist on certain conditions about the nature of the study process in negotiating either case-by-case or province-wide agreements. Relevant items identified in the Environment Canada evaluation study or in later basin studies carried out by the provinces include:

1. Continue to require a pre-planning stage and use it to establish a focus for planning studies -- During pre-planning, identify and define a small group of relevant issues to be addressed in the planning study and develop a work program for addressing these. If additional information is needed to sort or flesh out the issues or develop the work program, carry out the needed research at the pre-planning stage -- do not let this linger into the planning stage. Undertake sufficient work in the pre-planning stage to enable the development of sound estimates of the resources required to do the planning.

2. Adopt an iterative, cyclical approach to planning studies -- This would enable recommendations to be developed in stages throughout the study rather than all at the end. This could be conducive to faster response in terms of implementation for certain issues. It could also contribute to more effective public participation, and greater study flexibility by enabling a "structured review and reassessment process" as the planning study is occurring.

3. Assign priority to using secondary data sources -- Consider having two different types of planning studies -- an investigative study and an in-depth study. The investigative study would be limited to work based on secondary data sources. The in-depth study would use both secondary and primary data sources. The latter could be divided up so the part involving secondary data sources occurred first.

4. Place greater emphasis on developing practical and implementable recommendations -- This will require significant ongoing involvement of potential implementation agencies in the study program. Doing this may also reduce the transition time to implementation.

5. Provide for more flexibility in the study budgets -- This would allow for response to important unforeseen issues that emerge during the planning study.

6. Restrict the length of the planning study -- This should be no more than a year for an investigative study and two years for an in-depth study.

CHAPTER 3

SPECIFIC ISSUE ORIENTED AGREEMENTS

While the federal government originally sought to promote comprehensive river basin planning through The Canada Water Act, the provinces have frequently been interested in narrower, more specific water planning and implementation issues. In contrast to the comprehensive basin planning approach, provincial interests and requirements have often had the following characteristics:

1. concern over one or a small number of issues or problems rather than a wide range of these;

2. reference to a specific water body or a portion of a river basin rather than a whole river basin;

3. reaction to a problem that has emerged rather than anticipation of possible problems.

A major area of activity under The Canada Water Act has been issue specific federal-provincial agreements which, to a larger extent, address planning and implementation requirements that have been proposed or readily accepted by the provinces. Over 30 such agreements have been signed with the provinces under The Canada Water Act; this is almost triple the number of comprehensive river basin planning and implementation agreements. Most of these agreements are cost-shared on a 50/50 basis between the federal and provincial participants.

Tables 4, 5, 6, 7 and 8 indicate the status of these agreements for five topic or issue categories -- framework and specific issue planning (Table 4), flood protection and flow regulation (Table 5), water quality assessment or management (Table 6), major project impact assessment/mitigation (Table 7), and other agreement categories which include regulation and apportionment (Table 8).

Each agreement is listed once only. Where an agreement might fit into more than one category, we have arbitrarily assigned it

to the one we considered most appropriate. For example, the English-Wabigoon Mercury Contamination Agreement applies both to water quality assessment and major project impact assessment/mitigation; we have included it under major project impact assessment/mitigation because of its linkage to effluents from pulp and paper mills. These tables provide the basis for the following relevant insights about issue specific basin or water body oriented planning and implementation agreements:

1. The agreements encompass a wide variety of topics and issues including water supply system reliability, estuary planning, effects of urbanization, water resource development, flow regulation, flood control, water quality standards, sewage treatment technology, toxic substances in water, mercury pollution, project impact assessment, project impact mitigation, ecological inventory, water quality monitoring, water regulation and apportionment, shore damage surveys. For the most part, the agreements deal with the environmental and problem related aspects of water. This is consistent with the general orientation of Environment Canada which administers The Canada Water Act. A small number of agreements, including the Northern Ontario Water Resources and Yukon River Basin Agreements have focused on economic aspects and related opportunities. The Northern Ontario Water Resources project was initiated prior to enactment of The Canada Water Act.

   The variety of topics and issues covered in these agreements is indicative of a very flexible agreement framework capable of handling diverse interests and concerns as well as being adaptable to changing circumstances. This observation was reinforced also through discussions with provincial officials. While some complained that federal officials were being too restrictive in negotiating particular agreements, none considered the overall agreement framework to be inordinately restrictive. Several noted that the current agreement framework should continue, as it had proven quite adaptable in the past.

2. Issue specific agreements have been negotiated with all of the provinces. Five provinces have had five or more such agreements -- British Columbia, Saskatchewan, Manitoba, Ontario and Quebec. There have been fewer agreements with the remaining provinces either because of reluctance to participate in federal-provincial agreements (as in the case of Alberta) or because of the limited number of inland water issues that arise or can be deemed to be in the national interest (as in the case of the Atlantic provinces). The existence of multiple

issue specific agreements in many provinces, along with other federal-provincial agreement and non-agreement activities, has led to the formation of a host of federal-provincial agreements or project specific management and co-ordinating committees in many provinces. This is a source of concern of at least one province, New Brunswick, who would like to see this situation rationalized.

3. In contrast to the river basin planning agreements, there has been no noticeable decline in the number of issue specific federal-provincial agreements. Instead, the number of active agreements appears to have increased noticeably in recent years, i.e., moving from 13 active agreements in 1975-76 and 1980-81 to 19 in 1983-84.

   A continuing interest at the provincial level with issue specific agreements underlies this trend. Along with the growth in the number of agreements, there has been a small shift in the topics and issues covered. Agreements pertaining to framework and specific issue basin planning to flood protection and flow regulation and to major project impact assessment/mitigation have become more prevalent, while those related to implementation of the projects initiated prior to 1970 have become less prevalent. The changing pattern of topics and issues covered by agreements is a further indication of the adaptability of the issue oriented agreement framework.

Issue oriented agreements have become the mainstay of federal-provincial co-operation under The Canada Water Act. All provinces have participated in such agreements and, in general, provincial interest has been sustained. There is a good reason for this. The issue oriented agreements are quite flexible and open to provincial overtures. The agreements have permitted specific issues to be addressed on a water body or partial basin basis and they have often been used to react or respond to immediate problems. At the same time, provinces have the opportunity to take the lead in initiating an agreement. These characteristics are well suited to provincial requirements and to their sensitivity about federal infringement in areas of provincial jurisdiction.

Federal interests are also being served by this flexible agreement framework. It provides a highly adaptable mechanism for enticing the provinces to deal co-operatively with the federal government on an issue that may principally fall under provincial jurisdiction but may

also represent a federal concern. It is also a mechanism by which appropriate responses can be initiated to changing circumstances where federal-provincial co-operation is needed.

It is apparent from our review of agreements and discussions with provincial officials that one of the most enduring and appealing instruments of federal-provincial co-operation in the water area is the issue oriented agreement. If there is any single feature of the existing system that should be maintained into the future, this is it. There are two approaches that could be used in this area:

1. Issue Specific Agreements -- Essentially, this would be a continuation of the existing system. Specific water related issues would be addressed in individually negotiated federal-provincial agreements. Agreements on emerging issues could be entered into at any time. Either the provinces or the federal government could initiate a request for an agreement.

   Some changes in the process of deciding on agreements may be needed to adapt to reduced funding if fiscal constraint significantly affects this area of federal-provincial agreements. Under such circumstances, some flexibility would have to be reduced. For example, there may have to be a ceiling put on the amount of funding that goes to a particular province in a given year for such agreements; this might have to be broken down further into planning and implementation funding. Alternatively or additionally, topics and issues to be funded might have to be explicitly priorized according to the federal interest. The federal share of funding for proposed agreements might then vary according to these priorities. For example, for a top priority, the federal share would be 50 per cent; for a low priority it would be only 10 per cent. Any such changes, however, would not be well received by the provinces since the capacity to satisfy their interest would decline.

2. Umbrella Agreements -- Under this arrangement, the federal government would enter into an umbrella agreement with a province for a specific period of time (most likely, five years) pertaining to water programs. There would be provision for a series of issue specific subsidiary agreements within the umbrella agreement. Such an approach would be similar to the General Development Agreements or Economic and Regional Development Agreements used by DREE and DRIE. In the area of regional economic development, the arrangement could apply only to issue specific agreements or it could encompass a broader range

of federal-provincial activities related to water including, for example, the Flood Damage Reduction Agreement, Quantity Survey Agreements and joint projects not presently covered by the agreements.

An important advantage of the umbrella agreement approach is that it could provide a more focused and cohesive approach to federal-provincial involvement in the water area in provinces having such an agreement. It also would likely reduce duplication and overlap in negotiating, managing, co-ordinating and administering federal-provincial agreements and other activities in the provinces. This could be an important advantage in a period of fiscal constraint. An umbrella agreement approach would be conducive to the formation of a joint federal-provincial administrative group to oversee jointly sponsored water activity in the province. This would be one way of responding to the following suggestion made in New Brunswick's submission to the current Federal Inquiry: "the present arrangements with separate Federal-Provincial Agreements could be extended further to incorporate some kind of joint administrative group which would provide a co-ordinated focus for water administration in the province". Consolidation of this type also appears consistent with the trend toward consolidating water management functions in some provinces, e.g., in Saskatchewan, as noted previously, nearly all water related activities of the provincial government have been consolidated under the Saskatchewan Water Corporation. In New Brunswick, the office of Government Reform is considering recommendations to simplify water administration.

While an umbrella agreement could offer many advantages, it is not without problems. Such an arrangement might not be as well suited to responding to problems as they emerge. Such agreements are often for a specified period, e.g., five years, and subsidiary agreements are decided upon while the general agreement is being negotiated. New problems that emerge during the period of the agreement may have to wait to be addressed in a subsidiary agreement until a new general agreement is signed. Difficulties of this nature can be avoided to some extent, particularly in the case of smaller budget items, by having one or more subsidiary agreements that are somewhat open ended. For instance, the recently signed Manitoba ERDA contains a subsidiary agreement on Economic Development Planning that is quite general in nature and could accommodate a wide variety of planning studies. The main limiting factor in this subsidiary agreement is the budget limit.

Another problem could be that some provinces which presently participate in issue specifc agreements might refuse to participate in an umbrella agreement. This could lead to a fragmented

approach in which independently negotiated and operated agreements and projects would tend to dissipate the federal presence and reduce its influence in a province. An umbrella agreement might contribute to more cohesive and concentrated federal initiatives. This might be regarded as threatening by certain provinces which are especially sensitive to the matter of federal intrusion in the water area.

An especially difficult item to deal with in the umbrella agreement context would be federal-provincial agreements that involve several provinces. It would be virtually impossible to incorporate such agreements into subsidiary agreements of umbrella agreements, especially if some provinces chose not to enter into umbrella agreements. Most likely, such agreements would have to continue to be separate agreements outside of any umbrella agreement. This could noticeably reduce the advantage of umbrella agreements in some provinces.

CHAPTER 4

PROVINCE-WIDE AGREEMENTS

In addition to basin or water body oriented agreements, the federal government has entered into province-wide, federal-provincial agreements related to water. These agreements generally focus on one or two water topics and are usually applied to a number of water areas in a province. In contrast to basin or water body oriented agreements which occur only under the auspices of Environment Canada and The Canada Water Act, province-wide agreements have various sponsors. Some are sponsored by Environment Canada, but many are sponsored by other federal departments, in particular, the Department of Regional Industrial Expansion, and the former Department of Regional Economic Expansion.

Table 9 indicates the status of active programs sponsored by Environment Canada. Two main programs are involved, the Flood Damage Reduction Program and Water Quantity surveys. Efforts are presently under way to establish a Water Quality monitoring program. Both of the active programs were formalized several years after The Canada Water Act had been signed and, in both cases, the federal government has taken a leadership role in trying to get all provinces to participate in these programs. The programs represent a federal attempt to take a more co-ordinated and balanced approach to the topic. In each program there are certain principles to which the federal government and participating provinces are expected to adhere. The approach is co-operative in that participation by the provinces is voluntary and, beyond meeting the basic principles, there is considerable latitude to address each province's particular needs.

1. Flood Damage Reduction Program -- This pioneering program got under way in 1976 to replace what had in the past been a piece-meal approach by the federal government to deal with the problem of flood damages. It is intended to provide a comprehensive approach to the problem, rather than the generally narrow approaches that had typically been adopted in the past.

Central elements of the program have been the introduction of flood risk mapping and discouragement of further occupancy and development of high flood risk areas. Governments participating in the program must agree not to engage in, or to provide assistance for, undertakings that are vulnerable to flood damages in designated high flood risk areas. In such areas, federal disaster assistance will be restricted to structures built before designation and, in some circumstances, new structures that are flood proofed. Zoning on the basis of flood risk is encouraged.

The agreement structure of the program is innovative and quite adaptable. General Agreements are generally for a ten year period with the opportunity for amendment prior to that to incorporate needed changes or to extend the duration of the agreement. On entering the program, provinces also sign a Mapping Agreement. The General Agreement outlines the principles that will be adopted to reduce flood damages. The Mapping Agreements provide for flood risk mapping and designation of high flood risk areas. Additional province-wide sub-agreements such as a Flood Forecasting Agreement and a Studies Agreement can also be negotiated. As well, where requirements may emerge in some areas for costly flood protection projects, further agreements to study and implement such projects can be negotiated with the province. The latter would effectively be basin or water body oriented agreements dealing with flood protection (see Table 9). This means that the Flood Damage Reduction Program provides for both province-wide and basin or water body oriented agreements.

By 1982-83, eight provinces and territories were participating in the flood damage reduction program. Efforts are continuing to secure participation of the remaining three provinces and territories. This included Alberta and British Columbia, which have both been reluctant in recent years to participate in any federal-provincial programs. Although considerable time was involved in achieving the participation of the majority of provinces, this high level of participation and the extension of the duration of agreements with several provinces indicate the appeal and general appropriateness of this program as an instrument of federal-provincial co-operation. Concerns exist about the harshness of the designation process in some provinces, particularly Saskatchewan, which invoked a moratorium on designations in 1982. Some disagreement must be expected, however, in any such federal-provincial program where a condition for participation is the acceptance of a set of rather demanding principles established by the federal government.

2. Water Quantity Surveys -- Joint federal-provincial water quantity monitoring programs go back to 1894. For a long time

co-operation in this area occurred informally. In 1975, the relationship was formalized through signing of uniform cost-sharing agreements with each province. The agreements provide for a consistent approach to water quantity surveys across Canada and for sharing of the survey information between the federal and provincial governments. That agreements exist with all provinces is a solid indication of the desirability of this program. These surveys are regarded as a basic component of federal and provincial water research and management programs. In spite of their importance, water quantity surveys have been reduced in many areas as a result of government fiscal restraints.

As noted above, the federal government is also pursuing agreements across Canada on water quality monitoring. So far, an agreement has been reached with Quebec. The provincial submissions to the Inquiry and discussions held with provincial officials indicate a strong interest, in principle, for joint water quality monitoring. However, differences of opinion exist about the specific details of the monitoring systems. Here again, fiscal restraint is complicating the process. In spite of this, agreements are likely to be in place with most, if not all, of the provinces in the next few years.

Additional province-wide agreements are sponsored by other departments than Environment Canada. The nature and extent of such agreements varies from province to province. These agreements are especially significant in some of the western provinces where the Prairie Farm Rehabilitation Administration is active. Water related agreements in Manitoba since 1971, sponsored by other departments are presented in Table 10 (next page). The five agreements in this province provide a good indication of the type of activities sponsored by other departments throughout Canada. Table 10 indicates:

1. The major other department sponsoring water related federal-provincial agreements in Manitoba has been the Department of Regional Industrial Expansion (DRIE) and its predecessor, the Department of Regional Economic Expansion (DREE), which until recently included the Prairie Farm Rehabilitation Administration (PFRA). Three of five agreements in Manitoba were signed with this department. However, in the two most recent agreements, departments other than DRIE were the sponsors, i.e.,

TABLE 10

OTHER FEDERAL-PROVINCIAL AGREEMENTS ADDRESSING WATER IN MANITOBA SINCE 1971

Agreement	Timing	Lead Federal Agency	Activity	Water Related Subject Areas
Agricultural Service Centre Agreement	1972-1982	Dept. of Regional Economic Expansion (PFRA)	implementation	municipal water supply and waste disposal facilities
Canada-Manitoba interim subsidiary agreement on Water Development for Regional Economic Expansion and Drought Proofing	1980-1985	Dept. of Regional Economic Expansion (PFRA)	planning implementation	water supply and conservation; water management in water short areas; multiple purpose and diversion water supply projects
Canada-Manitoba subsidiary agreement on Value Added Crops Production	1978-1984	Dept. of Regional Economic Expansion	implementation	drainage and water conservation projects
Canada-Manitoba subsidiary agreement of Agri-Food Development	1984-	Dept. of Agriculture (PFRA)	implementation	organize conservation districts; drainage management and projects
Canada-Manitoba subsidiary agreement for Economic Development Planning	1984	Minister of State for Economic and Regional Development	planning	clarifying water issues in Manitoba

the Department of Agriculture and the Minister of State for Economic and Regional Development. This reflects the recent move of PFRA to the Department of Agriculture and also a change in approach in the way regional and economic federal-provincial agreements are organized and signed. In three of the agreements, PFRA, which has shifted back and forth between DRIE and Agriculture Canada, has been a major federal participant. Outside of the Inland Water Branch of Environment Canada, PFRA is the main federal water related agency operating in Manitoba.

2. The orientation of the agreements is toward the economic development aspects of water use. They focus on the commercial applications of water, in agriculture in particular, and on the role of water as an instrument or constraint to rural development. The emphasis is on making water-using applications more productive and in removing barriers to community and regional development that result from inadequate water supply or water supply systems. This focus on the economic dimensions of water can complement and conflict with the emphasis in Environment Canada agreements on the management and environmental aspects of water.

3. The agreements are predominantly oriented towards implementing water supply and management projects. A significant role is played by PFRA in delivering many of these projects. This is deemed to be a positive feature for the federal government as it enhances federal visibility.

4. Most of the agreements are subsidiary agreements to a general or umbrella Canada-Manitoba Agreement on economic and regional development. The two earlier subsidiary agreements are under the General Development Agreements of 1974, while the two recent subsidiary agreements are under the Economic and Regional Development Agreement of 1984. The latter replaces the General Development Agreement. Only the Agricultural Service Centre Agreement stands alone. In contrast, nearly all agreements sponsored by Environment Canada are "stand alone" agreements. The only exceptions are the sub-agreements under the Flood Damage Reduction Program.

It is apparent from the Manitoba situation that province-wide agreements sponsored by departments other than Environment Canada represent an important aspect of federal-provincial co-operation in regard to water. Agreement activity sponsored by other departments is very substantial in some provinces, possibly approaching and exceeding the level of activity sponsored by Environment Canada. The involvement of other departments in water related federal-provincial agreements introduces a

new dimension to this topic. It opens the possibility for competition among federal departments to sponsor water related agreements and also the opportunity for provinces to "shop around" for the best deal when they are interested in securing federal support. This has been a source of concern among Environment Canada officials in the Prairie Provinces, where at least one province (Saskatchewan) went to both Environment Canada and DRIE to get the best possible deal on some water related projects it wanted to pursue. Because it could provide 100 per cent funding of some projects, DRIE was at an advantage over Environment Canada which could at most 50/50 cost-share. Furthermore, projects sponsored by Environment Canada must have a benefit-cost ratio greater than one, whereas this has not always been the case for those sponsored by DRIE or the Department of Agriculture. The combination of competition among departments and imbalances in the capability of each department to respond can be detrimental to achieving a cohesive federal approach to federal-provincial co-operation in the water area. On the other hand, it can be advantageous to the provinces in that it gives them options for dealing with the federal government.

In regard to the area of province-wide agreements, several alternatives were identified in discussions with provincial officials:

1. Continuation of Existing Programs -- There was considerable interest in continuing the existing federal-provincial Flood Damage Reduction Program, the Water Quantity surveys and getting water quality monitoring agreements in place. Concerns exist about cutting back the water quantity surveys and suggestions were made that rather than cut back in this area, other agreements should be cut back more. There is a growing interest in eastern Canada, particularly New Brunswick and Prince Edward Island, in entering into an economically oriented agreement on water.

2. Possible New Areas for Province-Wide Programs -- Provincial officials in many provinces favoured having the federal government move into some new province-wide programs. Most recognized that this might be very difficult to accomplish with the increasing level of financial restraint at both the federal and provincial levels. Topics identified as possible candidates for such programs were:

(a) water pricing -- a province-wide program might be established to encourage provinces to adopt more comprehensive water pricing systems. The program could include joint participation in water valuation studies, design of pricing systems and design of implementation systems. Actual implementation would not be included since this would be regarded as excessive intrusion into provincial water management responsibilities. There appears to be a growing recognition that water pricing is an important dimension of future water management. The combination of increasing water scarcity and the need for revenues to offset fiscal cutbacks is making this an increasingly appealing option to consider. At the same time, individual provinces are reluctant to move into this area because if they act alone, the competitive position of their economies could be adversely affected. This seems to be an appropriate situation for federal leadership and a province-wide agreement program would appear to be a suitable mechanism. A key to being able to carry out such a program would be getting several provinces to enter into agreements at the same time during the initial phase of the program. For the reason noted above, it is unlikely that any province would be willing to be the first in.

(b) river basin planning -- province-wide agreements for this area were discussed earlier in the report.

(c) soil and water conservation districts -- Ontario and Manitoba both have conservation districts. Ontario's system is extensive and well established, while the one in Manitoba is more recent and small scale. These districts provide the opportunity for municipal governments to engage in region-wide water management. The suggestion was made by one provincial official interviewed that a province-wide federal program should be established to encourage more extensive development of soil and water conservation districts. The program could include assistance for establishing and operating such districts, preparing district conservation plans, undertaking demonstration projects, development of rural zoning systems and preparation of conservation management manuals. Specific conservation works would be subject to individual agreements. A key issue related to adopting this type of program is the uncertainty about how effective conservation districts can be. As noted earlier, there is much concern in Ontario about the inadequacies of their conservation authorities.

(d) upgrading and rehabilitation of municipal water supply and sewer systems -- officials from Saskatchewan, Manitoba, Ontario, New Brunswick, Nova Scotia and Prince Edward Island identified the need to rehabilitate and upgrade municipal water and sewer systems as a major area of concern and cost that is emerging for them. They all thought this was a key area that the federal government should cost-share with the provinces. Several noted the need for some kind of federal-provincial program that would be available to all provinces. An extensive review of this topic is being carried out in a separate study for the Inquiry.

(e) toxic contaminants -- this topic under a variety of names, including hazardous wastes, was identified by officials in Nova Scotia, Ontario, Prince Edward Island and Manitoba as needing special attention in the future. While work is currently under way on this topic within the federal and some provincial governments, more of an orientation to the water related aspects was required.

The variety of federal water related agencies led several people that we interviewed to make the following suggestion:

Consolidation of Federal Water Agencies -- With government fiscal constraints and growing interest in water management, a possible emerging trend is consolidation of water related activities within a government. Some provinces such as Manitoba have had a significant degree of consolidation of water related functions under the Water Resources Branch for many years. The most dramatic recent development on the provincial water scene in Canada has been the creation of the Saskatchewan Water Corporation, which consolidated a diverse array of that province's water related agencies. There are indications that New Brunswick may also be moving in the direction of consolidation. The idea of consolidating water related agencies could also be applied at the federal level. Several of the provincial officials that we spoke to suggested that it would be advantageous to consolidate the water related activities under Environment Canada, particularly the Inland Waters Branch and those under the Department of Agriculture (particularly PFRA) into a single agency or at least into a single department. The main reason given for this is that it would result in a more uniform approach by the federal government in its water related dealings with the provinces. Some of the confusion of dealing with the federal government would be reduced. There might be faster turnaround times in their dealings with the provinces as the direction could be clearer and interdepartmental consultation time might be reduced.

From the federal perspective, such a move could help to rationalize their water related activities and ensure a more cohesive approach to dealing with provinces on water issues. It could alleviate inter-departmental competition to participate in federal-provincial agreements and eliminate situations where provinces can shop around for the best deal on water agreements.

There are many different ways that water related agencies could be moved around to achieve consolidation. All will pose substantial problems. While opposition can be expected to most moves by the agencies making the move and the departments that are losing agencies, it is also apparent that such moves could produce significant mismatches for the departments receiving the added agencies. Also, such moves could change the present balance between environmental and economic development aspects of water in dealings with the province. If, for example, the consolidation was into DRIE, there would likely be more emphasis placed on the economic dimensions than at present; if the consolidation was into Environment Canada, there would be more emphasis on the environmental dimensions. Such shifts in emphasis would be viewed positively by some provinces and negatively by others.

An alternative approach to shifting agencies between existing departments would be to form a new Water Department. This would be analogous to the Saskatchewan approach. This approach would require the federal government to give water as an area of responsibility a much higher profile than it already has, which in the present climate, is difficult to see happening. For example, moving PFRA to such an organization would suggest that water considerations supercede economic development considerations. This clearly is not the case and is not likely to be for some time.

CHAPTER 5

NON-AGREEMENT ACTIVITIES

While the mainstay of federal-provincial co-operation in the water area has been federal-provincial agreements, there have also been co-operative federal and provincial activities outside the agreement sphere. There is very little information on these in the documents that we reviewed as part of this study; however, our discussion with provincial officials indicated that this was nevertheless an important aspect of federal-provincial co-operation. All of the officials that we interviewed mentioned this area and expressed a desire for more of this type of co-operation.

Owing to the limited documentation, this aspect of federal-provincial co-operation can only be addressed in a piecemeal manner. Based on the limited investigation undertaken, the following items pertinent to non-agreement activities have been identified:

1. The Canada Water Act proposed the formation of federal-provincial Consultative Committees on Water. These committees were supposed to meet periodically to review federal and provincial priorities and establish a basis for joint activity. While these committees appear to have been a good idea in principle, they did not materialize as planned and at present either they do not exist or are dormant in all provinces. Instead, their intended function has been handled through more casual discussions between senior federal and provincial officials who typically had numerous opportunities for contact through their involvement in management and co-ordination committees of the federal-provincial agreements. The Consultative Committees were considered redundant in this environment. Although these committees are not in operation, at least one variant of them exists. Senior federal and provincial water officials in the Atlantic provinces get together twice a year to exchange information and address relevant concerns and issues.

2. Exchanges of technical information occur between federal and provincial officials and scientists. This is sometimes done through formal channels after an exchange of letters or less formally through personal interaction. This is quite a common

form of federal-provincial co-operation and was highly regarded by officials in most provinces, including British Columbia and Quebec.

3. Joint projects are sometimes carried out between federal and provincial water agencies. The funds for these projects, which are handled outside an agreement framework, come from the budgets of the agencies involved. This type of activity occurs in situations where federal-provincial co-operation is needed but going the agreement route is inappropriate, e.g., where the size of the project is relatively small and a fast response is required. Pre-planning studies fall into this category. As noted in Tables 3 and 4, there have been at least six pre-planning studies done to date.

Non-agreement work-sharing activities will likely be a continuing feature of federal-provincial co-operation. For the most part, such activity occurs naturally and does not require significant policy initiatives. Some provincial officials thought that, in the future, with fiscal constraints becoming more pronounced, non-agreement activities would become more important because of their flexible and often low cost nature. In view of this possibility and the interest shown by provincial officials in this area, we suggest that a separate, more detailed study be undertaken on the non-agreement aspect of federal-provincial co-operation. The current study provides only a glimpse of this area.

Three suggestions were made about future possibilities in the non-agreement sphere that are relevant to federal-provincial co-operation:

1. <u>Contracting of Federal Expertise</u> -- The federal government, through its water research and management programs, has developed the best expertise in the country in many areas, e.g., toxic chemicals, complex water regime analysis. The suggestion was made that it should be willing to make that expertise available to provinces on a contract basis. Such an arrangement would give provinces access to this expertise in a form which would best serve their needs. While the provinces at present generally have some access to this expertise through intergovernmental channels, such access does not generally permit the exclusive use on a provincial project of the federal officials involved.

   This type of approach would be especially appealing to those provinces that are very concerned about federal infringement on provincial jurisdictions, since it could enable these and

other provinces to access federal resources without any loss of control. This may be one of the few ways of increasing the degree of federal-provincial interaction with such provinces. In terms of the federal government, it would be a revenue source; however, it would also likely be disruptive to the research and management activities being carried out at the federal level. Furthermore, provinces not using such a service might consider it an unfair advantage for those that do use it. In a similar vein, unpleasant situations could emerge if several provinces wanted to contract for a particular type of expertise at one time and not all could be serviced.

2. Sharing of Equipment and Personnel -- One provincial official noted that the federal and provincial governments have almost parallel activities going on in some areas. While these activities are generally oriented to different purposes (e.g., research at the federal level, day-to-day management at the provincial level), they involve similar types of equipment and personnel with similar backgrounds. An example was given of information gathering and water system modelling on the Great Lakes. Where such situations exist, federal agencies should be prepared to initiate or entertain discussions with appropriate provincial agencies for sharing of very expensive equipment and very specialized personnel. This would be done at the agency level, through agency budgets, rather than through a federal-provincial agreement. This official argued that growing government fiscal constraints could force this situation and prompt the agencies at both levels to forego some of their lesser objectives to achieve a resource sharing arrangement.

3. Policies and Priorities Committee -- Nova Scotia, in its submission to the Inquiry, suggested that there needed to be a formal mechanism that facilitates co-operation and co-ordination of federal and provincial water activities in a given province. Such a group would be responsible for proposing priorities and policy initiatives and being more anticipatory than the project specific, generally reactive consultative mechanisms that presently exist. This is very similar to the aforementioned federal-provincial Consultative Committees on Water which never really took hold. It could be, however, that in an environment of major fiscal constraint, such a mechanism could resurface out of the need to make better use of increasingly scarce federal and provincial resources for water management.

CHAPTER 6

CONCLUDING PERSPECTIVES

The review and assessment conducted during the course of this study has confirmed that, during the past fifteen years, there has been a great deal and wide variety of federal-provincial co-operation activity in the water area. Much of this co-operation has been formalized into federal-provincial agreements, although non-agreement activity has also been important. All provinces have participated in co-operative programs, some aggressively, others apprehensively.

Based on the experience to date as well as on an appreciation of current and anticipated water issues, it is clear that a continuing requirement exists for significant activity in the sphere of federal-provincial co-operation. This requirement may even be expanding as water related problems and opportunities become more widespread and complex. Notwithstanding underlying requirements, however, the actual amount of co-operative activity may very likely become reduced in the future, primarily as a result of federal and provincial governments' cutbacks on expenditures to control mounting deficits.

In this report, the range of existing programs and mechanisms for federal-provincial co-operation in the water field has been reviewed and a variety of alternative arrangements for federal-provincial co-operation in the future have been identified. Only a portion of these can be adopted, particularly with the increasingly constrained fiscal environment. While all alternatives merit consideration, some would seem to be more relevant than others. Probably most important is continuation of those arrangements and programs that have been well received and deemed to be effective to date. In particular, any future initiatives by the federal government should accommodate issue specific agreements. Such issue oriented agreements are flexible and tend to be responsive to changing priorities and fiscal circumstances. They are also attractive

in that they provide a more adaptive framework within which jurisdictional issues may more effectively be accommodated. Province-wide agreement programs, including the Flood Damage Reduction Program, water quantity survey program and a joint water quality monitoring program, merit priority consideration. Water pricing, with its revenue generating capabilities, will be increasingly appealing and merits examination as the basis for a province-wide program.

Any programs that could enhance federal and provincial government revenues or produce cost savings undoubtedly will warrant special attention in the future. In this regard, the suggested arrangements for co-ordinating agreements under a single umbrella, consolidating federal water related programs, sharing federal and provincial water related program resources and contracting of federal expertise could be relevant. While each of these arrangements will impinge on existing jurisdictions and preferences, the pressure of declining program resources may prompt the governments and agencies affected into activities that would not have been acceptable when the government fiscal environment was less strained.

Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

Research Papers

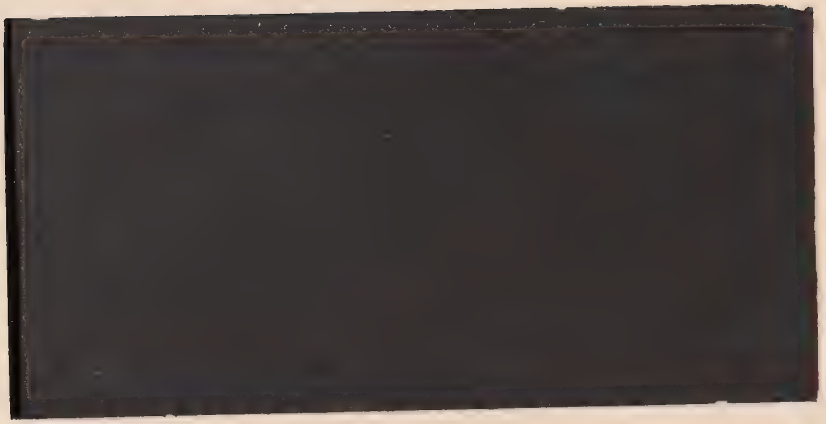
Documents de recherche

PUBLIC INFORMATION AND PUBLIC PARTICIPATION IN WATER RESOURCES POLICY

by

R.D. Schwass

Canada



Inquiry on Federal Water Policy
Research Paper # 10

PUBLIC INFORMATION AND PUBLIC PARTICIPATION IN WATER RESOURCES POLICY

by

R.D. Schwass

March 1985
Toronto

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A OH3.

Frank Quinn
Director of Research

Abstract

This paper includes a review of recent events and the results of a workshop discussion of public consultation issues with respect to federal water policy. Several suggestions are directed toward improvement of Environment Canada's public information and participation programs, and a national water commission is proposed. This Commission might, among other things, work with all levels of government to develop better public understanding of Canada's future issues and options.

Résumé

Ce rapport présente une revue des récents développements dans le domaine de la consultation du public de même que les résultats d'un atelier de travail sur les questions de consultation du public en ce qui a trait à la politique fédérale relative aux eaux. Plusieurs suggestions visant à l'amélioration des programmes d'information et de participation du public financés par Environnement Canada sont faites et une commission nationale de l'eau est proposée. Cette commission pourrait, entre autre, travailler avec tous les ordres de gouvernements afin de développer une meilleure compréhension des problèmes et options futures au Canada.

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APPENDICES

1. ACKNOWLEDGEMENTS:

In early 1985, after several discussions with Inquiry members and staff, I was asked to organize a small workshop to discuss the issues with respect to public information and public participation in the development of water resources policy and to present the findings of the workshop, together with other relevant materials, in the form of a brief report. This is the result.

At the workshop, fourteen people were brought together at the Cara Inn in Toronto, on February 4 and 5, 1985, to discuss the present situation, to define a more desirable future state of affairs, to discuss policy options and to make recommendations to the Inquiry.

The workshop members deserve credit for the ideas generated. The errors and omissions are mine.

2. INTRODUCTION:

Democratic societies require accurate and timely public information if they are to function properly. Public information and public participation allow the population to engage between elections in the process of policy development. There is general agreement in democratic societies that all areas of policy should be open to public review and reaction and that such participation usually results in better public policy, a more knowledgeable and contented electorate and more responsible government.

The environment is Canada's most pervasive reality. Not only does Canada have more environment per capita than any other nation, but we have an uniquely sensitive and inhospitable environment which requires substantial adaptation in human habits to be endurable and still other adaptations to render it sustainable under the pressures of population growth and rising expectations. The Inuit have survived for several thousand years in Canada's north and the Indians further south by creative adaptation to the environment. The environment was one of the pressures which maintained population at a low level in relation to land and water area. European settlers have greatly expanded output and numbers in the more hospitable parts of Canada and have subjugated nature to the point where traditional customs cannot be expected to yield a satisfactory living. The result is a society in the north which is not sustainable, based on present expectations and

population size, and which must be heavily subsidized from the south.

The analogy with the arid southwestern United States is clear. Vast growth in the Great Plains region, Colorado, New Mexico, Arizona and California has resulted from the flight of people of European culture to the arid "sunbelt" where new cultural patterns have been introduced. Intensive agriculture, dependent on large amounts of water, has expanded rapidly. The result is a society which is sustainable only if huge amounts of water can be added to the natural annual input. Until now, the water has been found by drawing on underground storage and the supply developed over thousands of years is being used in the space of less than one hundred. The sustainability of the U.S. sunbelt in the long run depends either on the abandonment of irrigated agriculture, on water subsidization of a massive kind, or on some combination of the two.

North America is a continent with the richest economy and population on Earth, which will have a population of nearly 600 millions by the year 2050. Of this number, about 35 millions will probably live in Canada; 375 millions in the U.S., of whom about half will be of Spanish and Mexican heritage and perhaps 200 millions in Mexico. The fastest growth in population will take place in the southern U.S., if sufficient water can be found or diverted there.

The Canadian prospect is not cheerful. Acid rain may decimate

Eastern Canadian forests before the causes are cleared up. One-half of the acid originates in Canada, one-half in the United States. No firm commitments have been made in the U.S. to do anything more than to study the problem. Water diversions from Lake Michigan to the Mississippi system have long been permitted and expanded diversions will be largely beyond Canadian control. There will be great pressure to expand diversions from the Great Lakes through Lakes Michigan and Erie to the point where system levels could only be maintained by damming the Severn, the Albany and the Winisk Rivers which empty into Hudson Bay, thus forcing fresh water back into the Great Lakes. The 50,000 Indians who would be dispossessed will have difficulty bargaining with the more than one hundred million beneficiaries in the United States, even with full support from all 25 million Canadians.

Similarly, plans for the North American Water and Power Alliance are being dusted off. Developed by Ralph M. Parsons Associates of Denver, in 1960, it proposed to dam the Liard, Slave and MacKenzie River systems and other north-flowing rivers to force water southward along the Rocky Mountain trench to replace the depleted reservoirs of the Great Plains and the California Lowland. The scheme may be technically feasible. The losers would be northern peoples and the beneficiaries would be southern peoples of this continent. The lack of warm spring waters, flowing into the Beaufort Sea at breakup, could retard the arrival of spring in the Arctic by some weeks and might well change the climate of Canada and the northeastern United States. The

project would flood vast areas of the north, displacing large numbers of native people and destroying wildlife habitat, both for native species and migratory birds which summer in the north and winter in the south.

It is for these reasons, among others, that the Inquiry on Federal Water Policy was created, and it is for these reasons that public information and public participation in the field of water resources planning will be so critical to the formulation of sound water resources policy in Canada and the United States in the next few years.

3. BACKGROUND TO THE REPORT

Early in 1985, the Inquiry asked me to proceed with a small Search Conference on the subject of public information and public participation. Participants were selected by Inquiry members and staff to represent key publics with an interest in the subject. With the help of Inquiry on Federal Water Policy and Environment Canada staff members, a Background Document was assembled and mailed to participants for their review before attending the Search Conference. An index of readings and a list of participants is attached.

The readings attempted to provide the knowledgeable public interest group representatives with some provocative ideas about current trends in environmental thought; the results of recent public opinion surveys; a review of strategies for public information and participation and a number of viewpoints about public information and participation which have been submitted to the Inquiry. Some highlights from the Background Document are summarized in the following sections, but the interested reader is invited to obtain a copy from the Inquiry office or from Environment Canada.

The workshop itself opened with a presentation by Charles Fremes of Decima Research and involved nearly two days of intensive discussion. The results of recent CROP and Canadian Trend surveys are summarized in Chapter 5 and the workshop proceedings including

introductory comments from the Decima polls, are summarized in Chapter [illegible].

4. THE EVOLUTION OF PUBLIC INFORMATION AND PUBLIC PARTICIPATION IN THE RESOURCES AREA

The terms "public information", "public involvement" and "public participation" have a variety of meanings in the literature. In general, public information is delivered by the responsible public authority or private interest group to the public. It is usually characterized as a "top-down" process, since information flows from the "top" to the "people" or "constituencies" or "publics". Public involvement usually refers to widespread information and discussion programs relating to a broad public issue (toxic waste management, plant modernization, etc.). It is also "top-down". Public participation usually describes a process in which large numbers of people and organizations are drawn into an exchange between the public or private agency (Berger Inquiry, Hartt Commission, Ontario Waste Management Corporation) and the individuals or interest groups most directly affected. Information flows upward from "publics" to the "top", as well as downward to the publics. Usually, although not always, public participation refers to specific proposed policy, legislation, regulation or action with direct and immediate effects on people or the natural environment.

Public participation in Canada has become an accepted part of the process of making major social and institutional choices since the early 1960s. Most Canadians support the idea that those who will be

affected by decisions should have a role in making them. There is somewhat less support for the "professional" public participation bodies which specialize in mobilizing local citizens whenever a proposed policy or program emerges in their area. There has also been an evolution in public participation efforts since the 1960s, when confrontation was the principal mode of intervention by the affected publics, to more complex forms of extended participation, environmental mediation and even "bidding" for projects among the communities which might receive the potential benefits.

Public discussion of broad, national resource issues has been spotty. A series of conferences was held at the Banff Centre from 1980 to 1984, covering such topics as: Forestry in Canada; Canadian Water Resources; Northern Conservation (held in Whitehorse); Environmental Protection vs. Development; and Transforming Western Agricultural After the Crow. These events have engaged key decision-makers from across the country in searches for sound long-term policy for a sustainable natural resources base and a protected natural environment in Canada and have had some lasting impact on policy. For example, the Task Force on Northern Conservation was created as the direct result of the Whitehorse conference on northern conservation.

In the international field, the Great Lakes Institute, formed in the 1950s by Dr. George Langford and others, led to the formation of the Canada Centre for Inland Waters, devoted to physical research with

respect to the Great Lakes. In the early 1970s, there was extensive discussion of the concept of mobilizing cross-national constituencies around the Great Lakes region to influence state, provincial and national planning on both sides of the border.

Public participation techniques are numerous, but there has been little effort to evaluate their effectiveness. This is partly because several techniques may be used in a particular case and partly because it is extremely difficult to determine what factors led to a particular outcome and what weight should be given to the role of public participation. Managers of public participation programs should know and understand the strengths and limitations of various techniques, should specify the goals they hope to achieve and should then choose those techniques which will achieve their goals at least cost.

There are a number of serious constraints on the effectiveness of public participation in water resources planning . First, public participation does not transfer the authority and duty for making decisions from those who are responsible to those who merely want to participate. Secondly, time and money are often scarce, especially for public-interest groups, which often find themselves pitted against public bodies with funds, technical expertise and political knowledge. Thirdly, members of the public may feel with good reason, that the public body always has its mind made up before it undertakes the public participation program and that intervention, however necessary, may be

fruitless. On the other hand, public bodies may feel that public participation efforts will merely bring out opposition, not thoughtful discussion of alternatives or improvements. Finally, and this is especially true of large-scale, interjurisdictional issues such as water resources planning, the issues may be so numerous, diffuse and long-term in nature that it is difficult to mobilize people and money to undertake public participation. The result is "the tragedy of the commons" in which no one can afford to spend the time and money to intervene on behalf of our common natural heritage, with the result that its qualities are irreparably damaged.(1)

There is plenty of evidence, however, that effective public participation in the planning process clarifies issues, reduces misapprehensions, softens hardened and one-sided viewpoints and facilitates the resolution of differences. By providing opportunities for articulation of these diverse and strongly held views, public involvement can make for easier resolution of conflicts.

Adequate public participation requires rules.(2) Participation must begin early in the planning process. Notice must be provided to inform the publics of the planning activity and the opportunities for participation. Forums must be provided to have the views of publics heard throughout the planning process, especially preceding important decisions. Information should be complete, so participation can be informed, responsible and substantive. Planners must assimilate public

inputs and place them in perspective with all the other information which must be taken into account in making the decision. Final decisions should be made openly by the responsible officials. Schedules and deadlines should be set and kept to avoid delays and to permit early decisions.

The National Water Commission in the United States, which reported in 1972, set out key access points for public participation in the water resources planning process as follows:

- Planning agency communicates with publics concerning initial consideration of study, proposed scope and opportunities for public participation;
- Identification of study goals and objectives;
- Evaluation of resources; their availability and capability of meeting needs;
- Formulation and evaluation of alternative plans;
- Assessment of plans in light of costs and benefits in achieving originally hypothesized goals and objectives; and, as a result, reassessment of original goals and objectives;
- Reformulation and evaluation of alternative plans;
- Recommendation of a plan;
- Review of the plan. (3)

There are many techniques for public participation. Jerry Delli Priscoli (4) has attempted to evaluate various techniques for use in

achieving various goals. (see page 15) He has marked with an X those techniques which appear to be most effective in achieving certain goals. Thus, field techniques are best suited to evaluating broad service goals, workshops are best suited to water resources planning, and field offices for monitoring. Workshops, if properly structured with clearly defined roles and objectives, can provide interesting evaluations of alternatives, impact locations and potential reactions. They offer unique opportunities ranging from graphic display to encounter techniques. (5)

Similarly, such techniques as simulation, gaming and expert paneling can be used for technology assessment, research design, data generation and evaluation. Combined with workshops and citizen advisory committees, they help to develop value preference profiles on key issues.

The best technique to determine values and attitudes of widely distributed "regional publics" such as those in the Great Lakes Basin, the Great Plains or the St. Lawrence Watershed, is survey research. Specialized market research firms undertake specific survey packages, often attached to routine surveys which are conducted several times each year. Attitude, opinion and value surveys, when combined with theoretical research, can provide a solid foundation for policy and action. The weakness of such polls is that they are susceptible to media reports and can change drastically for a short period when an

TABLE 1
SUGGESTIVE RELATIONSHIP OF GOALS AND
POTENTIAL TECHNIQUES OF PUBLIC PARTICIPATION

GOALS / NIQUES	DATA GENERATING			EVALUATION			BROAD SERVICE			
	Needs Id.	Issue Id.	Goals Id.	Alternative Action	Impact Location	Impact Reactions	Sounding Board	Rep. Public	Public Acceptance	Broad Consens
CAC's							X	X	X	X
TA	X	X	X	X	X	X				
Monitoring System					X	X	X			
Advocacy				X		X	X	X	X	
Ombudsman						X	X	X		X
Telecomm.	X	X	X			X	X			
Part. Observ.	X	X	X		X	X				
Offices					X	X	X			
Workshops				X	X	X	X	X		
Demonst. Projects									X	X
Gaming				X	X	X				
Role Playing				X	X	X				
Mute Courts							X		X	
Brain-storming	X	X	X	X	X	X				
Delphi				X	X	X				
Policy Capturing	X	X	X				X			
Attitude & Opinion	X	X	X		X	X		X		
Value	X	X	X		X	X		X		
Mini	X	X	X		X	X		X		
Election Data		X	X		X	X		X		
Geo-Coding Census	X		X		X					
Secondary Survey	X	X	X							
Referendums	X	X	X					X	X	X
Votes								X	X	X
Campaign Issues								X	X	X

CAGs - Citizen's Advisory Committees (Groups)
TA - Technology Assessment
Mini - Mini Surveys

issue such as acid rain or toxic waste is "in the news". By the time longer-term policy action is taken, the public support may appear to have waned.

Once having established the goals, the best general policy is the use of multiple techniques built on the integration of a wide range of expertise, government officials and the general public. (6)

It is most important to distinguish when activity BY-people or a region is needed as opposed to data and projections ABOUT-people in a region. The first calls for selective recuitment of opinion-leading elites. The second requires social science expertise. Correct phasing of these elements in the decision-making environment is critical. (7)

Finally, multiple links between decision-makers and the publics should be maintained. No one group of citizens or techniques will be representative of the public, so several are essential to provide checks on individual sources. Public participation requires clear goals and a careful choice of techniques, or it can be dangerous to the democratic system itself. In the words of Samuel Huntington:

> "To the extent that Americans become carried away by their political ideals, they are in danger of doing away with their political institutions." (8)

5. CANADIAN ATTITUDES TO THE ENVIRONMENT AND WATER RESOURCES

The objective of public information programs is to provide the public with accurate material with which to form opinion. Public participation may occur because people feel the need to send their views to senior decision- makers, to ensure that action occurs in the direction they prefer. Public policymaking is no longer merely the domain of the senior politician or bureaucrat. The Canadian public has witnessed what it perceives as major policy errors in both Canada and the United States in recent years and there is deep skepticism about the quality of decision-making at the top. The informed and educated citizen wants to have sound information at the time policy is being made, and he/she wants a voice in final policy choices, without having to wait for years for an electoral opportunity to change governments.

This is not as new as it seems. Powerful voluntary (non-governmental) organizations have existed in this country since the mid-1800s. Many of them, such as the Mechanics' Institutes, the Workers' Educational Associations, the Grange, the Women's Institutes, Citizens' Forums, Canadian Association for Adult Education, Canadian Institute for International Affairs, Canadian Institute for Public Affairs, etc. were and are almost purely educational in nature, with most information flowing from the top down. Many others, however, including the Grain Growers' Grain Company, the Wheat Pools, the Federations of Agriculture, Farmers' Unions, Farm Radio Forums, labour

unions, Canadian Institute for Public Policy, Pollution and Energy Probe, National Survival Institute, various native organizations, etc., were and are intended to engage directly with governments in the process of developing and reflecting the opinions of various publics and ensuring that their views are taken into account in policymaking. Some of these have been single-topic, single-constituency or single-issue organizations, but many others have engaged in the evolution of policy over a broad range of issues.

The quality of the environment in general, and the condition of air and water in particular, began receiving keen attention in the late 1950s. "Silent Spring", a book on environmental degradation by United States writer Rachel Carson, focussed attention on the issue. In Canada, the National Film Board, Canadian Broadcasting Corporation (CBC) and other media, began to find and describe air and water quality issues in such industrial centres as Sarnia, Hamilton, Dunnville and even in remote locations (Long Harbour, Newfoundland, White Dog and Grassy Narrows Reserves, Ontario, and Yellowknife, N.W.T.) Medicine discovered allergies and their causes. Science discovered ways to measure emissions from stacks, ambient air quality, emissions from waste disposal discharges and ambient water quality. Technology was developed to obtain increasingly accurate readings, so the sampling of extremely small amounts of toxic substances in water became possible and practical. Science also began to discover the effects of mercury on the human brain, D.D.T. on reproduction,

thalidomide on cell development, dioxin, P.C.B. and diethylstilbestrol on the evolution of cancers. The public became aware of the rising acidity of water and its potentially disastrous effect when a toxic theshold would be reached. It became clear that a major constraint on economic growth would have to be the preservation of the environment, whatever the economic cost might be. A steadily rising standard of living is of little perceived benefit to a population whose life cycle could be shortened by the process of environmental degradation.

The result has been an escalation of long-term concern about the quality of the environment and especially of air and water. It was reflected in the Resources For Tomorrow Conference in 1962, the Pollution Conference in 1966 and the formation of the C.C.R.E.M. (Canadian Council of Resource and Environment Ministers). The formation of the Federal Department of the Environment and similar departments at the provincial level was the official sign of institutionalized public concern. The Stockholm Conference in 1972 reflected growing global awareness. A full range of environmental legislation was developed and brought into force in Canada during the 1970s and environmental regulation began in earnest. The university system established both undergraduate and graduate programs in environmental studies and environmental design, to provide trained practitioners in the holistic field of environmental studies, while traditional science and administrative studies faculties provided scientists and administrators. The media hired trained reporters to

maintain contact with all of their sources of information and to keep the public informed.

he result has been to develop a much higher level of interest in and concern about the environment. The average citizen is now aware that ten thousand new chemical compounds emerge each year from the laboratories. Of these, some will be valuable additions to the family of useful substances now is use. Many will be discarded as having no further use. Testing all the valuable or useful substances for potential toxicity of some kind at some further date is clearly impossible, either technically or financially. While much testing is done, everyone recognizes that there can be future discoveries about the impact of new materials (or older and more common ones) on some aspect of the biological cycle. People have lost confidence in the willingness or ability of the private businessman to abandon new materials merely because they are toxic or to take all possible steps to clean up his effluent. Since no businessman can clean up without raising his costs, people have turned their attention to government in an effort to legislate the careful testing of new compounds and the regulation of effluents into the environment. The process of bringing about a cleaner and healthier environment has turned out to be much more difficult and expensive than anyone expected, but it appears likely to continue. Businessmen have discovered that, so long as everyone must live by the new rules, no one suffers competitively. Recycling toxic wastes has turned out to be profitable, and the

development of new technology makes export sales possible.

Despite the progress that is being made, the level of interest in and concern about environmental issues is still high. Environment Canada subscribes to periodic surveys of public opinion: the CROP Report, the Canadian Trend Report, and the Decima Quarterly Report. Both CROP and Decima communicate the results of interviews held with representative samples of adult Canadians in which they are asked a series of questions on subjects ranging from politics and the economy to eating and reading habits. By posing the same questions over time, these two polls identify short and long-term trends in both public opinion and behaviour and analyze them according to a number of social and demographic factors. The CROP survey is taken five times per year, while the Decima poll occurs four times per year. The Trend Report studies the content of about 100 daily and weekly newspapers for the quality of coverage given to major subject areas and to the main topics within them. Based on the amount of coverage and analysis of the actual content, Trend identifies continuing and emerging issues and concerns.

In reading the following poll results, it is important to keep in mind the transitory nature of public attitudes. People respond to pollsters with answers which often reflect the morning paper or the journal the night before. Nevertheless, there is consistency in the growth of concern about environmental quality and in the desire of

Canadians to put the environment close to the top of all priorities of government.

Recent trends show a growing sense that government is incapable of dealing with economic issues, but should be responsible for environmental ones. While small business is preferred to big business, both are seen as largely self-serving. There is a growing belief in "voluntarism" - the belief that individuals can influence government and business and can help one another through voluntary group action, rather than through elected officials or other traditional institutions. This trend is ascribed to the public perception that the government and other institutions have failed to meet their needs in economic hard times. Canadians are therefore questioning the role of government and its attendant costs. Sixty percent (60%) of those interviewed told CROP in October 1984, that government is too involved in the lives of Canadians. Decima reports that seventy-nine percent (79%) of Canadians feel the Federal Government is doing a poor job of controlling its spending.

All the surveys show a strong consensus on the need for co-operation, consultation and the breaking down of artificial barriers, especially among governments, industry and labour. People are almost as interested in the decision-making process as they are in the final decision.

The three surveys reflect growing concern about the environment and a demand for government initiative. One in four Canadians identify the environment as the most important non-economic issue which should receive attention. Press coverage of environment issues has risen forty percent (40%) between 1983 and 1984. There is a strong demand for long-term "prevention policies" rather than crisis intervention and a "multiple-issue approach" which recognizes the interrelationship of environment problems. Concerns are broadening from the national to the international level, reflecting the emergence of concerns about the ozone layer, the greenhouse effect and acid rain.

Seventy-one percent (71%) of Canadians do not believe we have to accept higher pollution levels to provide for our future needs. Eighty percent (80%) of Canadians in the most recent Decima poll believe "protecting the environment" is primarily the responsibility of government, with only eleven percent (11%) identifying industry and six percent (6%) the voluntary sector. Government's role should be regulatory and monitoring, rather than financing. Big business, according to eighty-nine percent (89%) of those polled by CROP, should take the responsibility for actually implementing and paying for pollution control measures. Only fifteen percent (15%) of Canadians favour using tax dollars to subsidize pollution reduction.

Trend Report and CROP agree on the three priority issues of public

concern; water pollution, acid rain, and toxic chemicals. The public is increasingly concerned with water and health, not only with the older question of sewage and its treatment, but with the "new" problems of the seepage of toxics from industrial waste sites and municipal dumps into drinking water supplies. Seventy-four percent (74%) are extremely concerned about air pollution and acid rain (80% in Ontario, 84% in Quebec) and potential human effects. There is broad support for the view that the source in both Canada and the United States should be cleaned up as quickly as possible.

It is obvious that public information and participation programs are of extreme interest and importance in the management of issues and the evolution of policy. There is ample evidence of the staying power and enduring strength of the public's environmental concerns. Canadian Trend, in a recent report to Environment Canada, made a number of sensible recommendations. (9)

1. Environmental issues should be addressed on a long-term basis. Both leadership and commitment must be demonstrated. Short-term or narrow remedial strategies which ignore the rights of future generations will backfire.

2. In Canada, "environmentalists" are not narrow, single-issue, special interest extremists, but middle-class Canadians. All environmental issues will get a high profile in the media because

there is a huge audience of Canadians who identify on a deeply personal level with environmental issues and who project their concerns further into the future, as concern for the welfare of their families. This politicization is unlikely to be reversed.

3. Economic and social concerns blend with environmental concerns. Education, environmental protection and labour adjustment to technology, for instance, are all seen as intimately interrelated with the public notion of "environmental". Attempts to couch environmental concerns in terms of "jobs versus the environment" are likely to fail flat.

4. Environmental questions are especially sensitive and emotional because of the pervasive and intensifying concern about the future for today's youth. Professional terms such as "exploitation", "mutation" and "sterilization" are likely to conjure up terrifying, negative images for the average Canadian.

5. There is a receptive climate for bold initiatives and pro-active approaches. Canadians are far ahead of policymakers in their willingness to advance new, innovative environmental policies. The public's view of what is "actionable" needs to be heard.

6. Non-confrontational, open approaches to policymaking, that stress the legitimacy of all interests and the need for collaborative

development of new policies for an era of transition will resonate favourably with the Canadian public. Canadians believe that environmental questions are moral values accessible to all, rather than a subject for experts alone. Environmental decisions, whether within public or private institutions, are expected to be accessible, open to view and participation and responsive to public input.

7. Both "top-down" and "bottom-up" communication processes must be used. The most successful strategy and communications policy is one that builds out horizontally among employee groups and colleagues rather than one that is orchestrated down from senior management, professionals or experts, or one that is shaped only from "bottom-up" pressures from special interest groups. A sound, pervasive and workable environmental strategy requires communication and mutual action at all levels in the system.

6. THE WORKSHOP

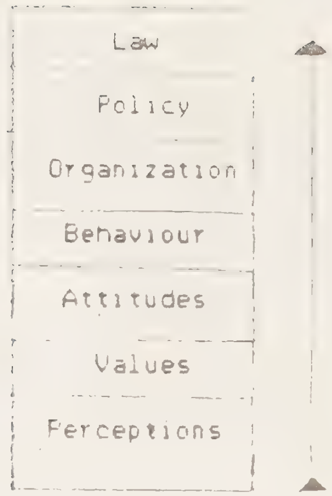
Because of its small size, the workshop did not break into small groups, nor did it complete all the steps of the proposed agenda. Three of the five themes were covered:

1. The Situation We Are In and Where It Will Lead If Present Trends Continue;
2. The Desirable Future;
3. Options and Recommendations.

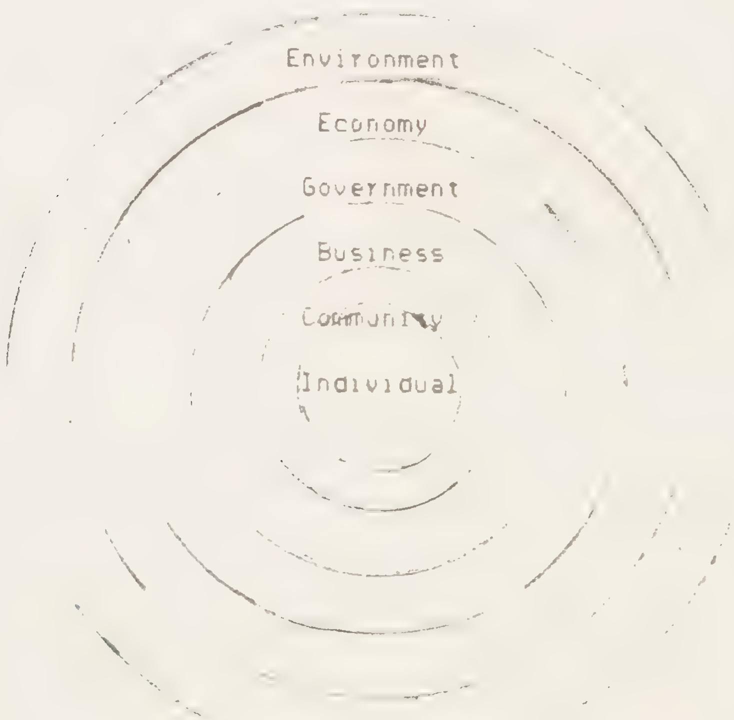
1. THE SITUATION WE ARE IN AND WHERE IT WILL LEAD IF PRESENT TRENDS CONTINUE

The following summary of the discussion was prepared from the flip charts used to record group dicussion.

An initial presentation was made by Charles Fremes of Decima Research. He showed a model of public policymaking in which a hierarchy of factors, beginning with public perceptions, values and attitudes leads to the evolution of public policy and law. The concept was shown as follows.



A second way of showing how public perception becomes the basis for policymaking and the formulation of laws might be:



Recent polls by a number of polling firms (Decima, Canadian Trends, CROP) were reviewed (see previous chapter) and their

implications examined in detail. Extensive discussion about the perceived relationship between the environment and the economy resulted in general agreement that a clean environment and a growing and productive economy should be jointly pursued. If both goals cannot be achieved together, the goal of environmental protection and the maintenance of a clean environment should rank ahead of the goal of a sound and productive economy.

Fremes made the point that underlying values are much slower to change than attitudes, and form the bedrock of public policy. Attitudes may move as issues (acid rain, etc.) are identified, while values (basic concern about nature and the quality of the environment) remain constant.

Current Canadian priorities centre on finding a means to resolving conflict and confrontation by reconciling the interests of the contending forces in society and to find consensus on goals and the policies needed to achieve them.

Canadians have a strong commitment to equity as a value, but recent polls show that attitudes are moving from support for expanded governmental activity to achieve equity to a public acceptance that reduced Federal government services may be necessary and that the pursuit of equity may have to be attempted by other levels of government, and by labour and the private sector. There is growing

concern with the deficit as a national problem and nearly eighty-five percent (85%) of those polled believe that the size of government and the quality of management in government is the main cause of the deficit. A similar number of people support cuts in programs which do not affect them personally.

An overwhelming majority of Canadians regard environmental issues as either very important or important. Regarded as very important or important are water pollution (96%), air pollution (93%), chemical or toxic wastes (90%), chemicals in food (92%), acid rain (87%), and oil spills (87%). "People in Canada believe they're entitled to the cleanest water in the world".

Canadians have developed clear-cut views about the credibility of information. Forty-six percent (46%) trust environmental groups, thirty-five percent (35%) trust government statistics and statements, and thirteen percent (13%) trust statements of private sector organizations and their representatives.

To solve problems, Canadians take individual action (7%), join an existing group (48%), form a new group (20%) or turn to their political leaders to find a solution (24%).

Canadians believe the private sector should be responsible for preventing pollution (39%) but if the private sector fails to take

action, it should be the responsibility of the Federal Government (23%), the provincial government (20%), or the private citizen (15%), to take action. In the past two years, attitudes have shifted responsibility slightly from the Federal Government and the individual to the provinces and private industry.

If environmental standards cannot be met by industry, and if the decision is to close a plant or take action to keep it open by having government pay part of the cost of renovation, fifty-seven percent (57%) of Canadians prefer to keep the plant open and have government pay part of the cost of renovation; thirty-four (34%) prefer to force the plant to close and five percent (5%) are prepared to have it remain open without renovation, in order to preserve jobs.

When asked whether environmental protection should be relaxed in order to promote economic growth, eighty-six percent (86%) of Canadians support present levels of protection, and only thirteen percent (13%) believe present environmental legislation should be relaxed to help the economy expand. If the choice is between protecting the environment and facing higher prices or reducing protection and enjoying lower prices, eighty-three percent (83%) of Canadians prefer to face higher prices. If the choice is between protecting the environment or reducing the number of jobs available, sixty-four percent (64%) vote to protect the environment and twenty-seven percent (27%) favour protection to be reduced to generate jobs.

These responses are unique. No other topic generates such strong and sustained commitment. Environmental protection appears to be closer to a value than an attitude among Canadians and in general, commitment to it has actually grown during the recent recession. Even among values, commitment to it ranks with Canadians among such values as participation, equality, and family. There is the basis for a powerful, national effort, shared by all individuals and groups, to maintain and improve the environment.

The presentation led to an extensive discussion of the present situation and probable future directions if present trends continue. The Big Generation of highly educated, young urban professionals have become the largest voting group and will remain in this position throughout their life cycle. They can be expected to be well-informed, participative and politically active. There was extensive discussion about the possible impact of their involvement in business, provincial and federal governments and non-governmental organizations over the next few years. Present models of public participation were developed during the late 1960s and 1970s, in response to an intense public desire to participate in policy development. Since 1980, there has been a reduction in the intensity of interest in direct participation, with the possible exception of such highly-charged issues as toxic wastes and acid rain. Even though most Canadians favour clean and abundant water supplies, etc., participation at the open hearings of

the Inquiry has been very disappointing.

One problem may be that people are not sure what an improved system of water and land management would be like. How would it operate? Who would have jurisdiction? What rights and privileges now enjoyed by Canadians would be reduced if it were implemented? Would it accomplish useful objectives with respect to our position within the continental water system?

If the environmental ethic is so strong, why has the current government chosen to make severe cuts in the budget of Environment Canada? Will these cuts have serious potential to damage programs which Canadians regard as essential? Is there sufficient fat in the Department of the Environment to absorb cuts without loss of environmental protection? Is it possible for the private sector, labour, non-governmental organizations and individuals to take larger responsiblity, thus allowing federal expenditures on environmental protection to be reduced without damage? What is necessry to change individual, corporate and governmental behaviour in line with the apparent environmental value or ethic which the polls appear to show? What kind of public participation system would be needed to mobilize such widespread change of behaviour?

A lengthy discussion followed about United States attitudes to environment, and especially to water resources. The United States

Clean Water Act was passed in the late 1970s with the objective of ending all toxic discharges into waterways by 1985. This goal has since been abandoned, as the full cost of accomplishing it has become clearer. The Act may be unenforceable, since it is probably technically and economically impossible to remove 100% of pollution from water. A lesser objective (95%) may be technically and economically feasible and may be equally acceptable to the public. An economic impact statement is now routinely prepared on every new piece of environmental legislation brought forward in the United States. It examines the impact on jobs and the economy and reflects the United States decision to put economic growth and job creation ahead of environment protection. This mandate from the United States voters elected Reagan and seems likely to remain in place for some time.

A major problem with respect to public understanding of environmental issues and the development of suitable public participation programs is that many questions cannot be answered with current scientific knowledge. Toxic substances cannot always be identified until they are in widespread use and their effects have pervaded the system. Up to 10,000 new chemical compounds are identified in the laboratories of the world each year and it is not possible to subject all of them to long-term testing before introduction. Much more knowledge is required before levels of risk can be positively established. There are few mechanisms by which the public can interact with scientists to describe their needs for

information.

Canadians are perceived to be scientific illiterates. It could take from twenty to forty years to make most Canadians aware of the scientific realities of environmental issues. Reliable information is not available for either students or adults, either on the scientific basis for environmental realities or on means by which environmental damage can be avoided. The result is that most people simply do not know how to respond to their institutions and governments, other than to say they prefer a clean environment to a dangerous, dirty and toxic one. Ways must be found to extract more information from scientists and governments and to digest it for public use.

The role of the Inquiry received extensive attention. It was felt that the public lacks a clear definiton of its role, and this might account for the limited attendance at hearings. Seven out of twelve provinces and territories presented briefs. Of the five that did not, three responded that the issue of water was a provincial responsibility under the Constitution and was therefore not the proper subject of Federal examination. Two hundred and fifty briefs were submitted by public interest groups. Press reaction has been good, but local in nature, focussing mostly on the content of briefs submitted locally and not on national and international issues. It was agreed that the Inquiry had a most important consultative role to play; that it could have a profound impact on public attitudes to water resource

quality and supply, and that it should recommend a range of strategic and practical programs which Canadians, their organizations and governments, could implement. It is essential that it be taken seriously by all levels of government. This means that academics, consultants, heads of agencies with reponsibility for water resources, as well as the public, must be convinced by the Inquiry Report. Change but not panic should be the goal. A change in long-term cultural behaviour is required in Canadian society to achieve it.

2. THE DESIRABLE FUTURE

The desirable future should include environmental accomplishments such as; safe drinking water for all Canadians, safe habitat for fish, the resolution of trans-boundary water issues between the United States and Canada, the development of widespread public participation systems to allow Canadians to intervene in policymaking and the completion of a powerful, technically sound report by the Inquiry which could be used across Canada for public information and participation.

The group examined each of these important goals in turn.

With respect to the provision of safe drinking water for all Canadians, it will be necessary to eliminate the widespread pollution of Canadian water sources by both domestic and United States polluters. Lake Ontario water is being polluted continuously, mostly from the United States side, and its condition grows steadily worse. A desirable future would lead to resolution of such situations, by means of national and international media campaigns and direct-mail solicitation, especially with elected United States officials. The development of a Clean-Water Act similar to the Clean-Air Act, will be required.

One group member expressed the strongly-held view that we have deluded ourselves by believing that "environmental management" is

possible and sufficient to restore our environment to a healthy and satisfactory state. Such "management" has been dominated by economic imperatives and therefore has fallen far short of the "environmental nurturing" which is needed if the environment is to be maintained and restored to a healthy and sustainable state. Since governments seem unwilling to assume this role, it is imperative that non-governmental organizations assume the nurturing role. Young people, women and others must develop groups aimed at raising the consciousness of the society with respect to the environment, with the goal of developing a new environmental paradigm, or world-view, which clearly puts the quality of the environment ahead of economic issues. "Soft environment paths" must be developed, in contrast to the path of environmental protection legislation, which industry and government seem to prefer.

Such "soft paths" might involve smaller-scale, cleaner technology which recycle all effluents or confine them for safe disposal. They should be developed for both small and large companies and would be self-financing or perhaps aided by government, as large installations often are for big industry. They should be environmentally benign and compatible with larger systems, and should be capable of substantial long-term environmental savings. They would be the technological extension of the "conserver society" in which recycling, reduction, reclamation, reuse, and replacement are the key concepts.

To achieve such a desirable future, it will be necessary to make

it possible for the urban householder - whether an owner or a tenant - to be aware of what goes into his home and what comes out. At the moment, few people can obtain such information. It is not possible to compare one's pollution with "normal" levels by others, nor to rate household equipment according to its frugality of water use, or its impact on the quality of water leaving the home. Unlike metering systems for gas or electricity or the technology used in cars and equipment, technologies are not in use to report on efficiency of water use or the quality of effluent, nor are large central systems able to reward conservers nor to punish over-users or polluters. There is no conscious knowledge of the impact of hazardous household wastes on the water environment. Urban people have lost contact with their water environment, in terms of volume, scarcity, and price. It should be a major goal of the Inquiry to bring them into contact with the realities of their water environment.

In a desirable future, large issues and their resolution should be connected directly to the "realities of living". People have the capacity to implement solutions if they understand and become concerned about a problem and have knowledge of the consequences of their personal actions and the steps necessary to change them in the direction of a cleaner environment. Although price is the usual signal, other signals may be needed.

In a desirable future, publishers of all forms of literature,

including educational texts and children's books, will be involved. There is at present a limited market in Canada, but the Great Lakes Basin market would be much larger. The St. Lawrence Basin or the Great Plains Region would also constitute a large market. It is essential to define common ground, where the focus is an environmental community, centred on a shared resource with less concern for the Canada-United States border. Then specific publics can be targeted by publishers, cable television, and other media. Publics would include private citizens, rural and urban community leaders, industry leaders, professionals, government, and academic leaders.

It was suggested that a desirable approach might resemble the drunk-driving campaigns which have been launched. The "Aware" program in Saskatchewan was lauded as one of the best in Canada and a possible model for future "water-awareness" programs. Politicians must be convinced by grass-roots pressure and action that water issues are extremely important to Canadians. Clean water must be seen as both a health and an environmental issue, since lakes, streams and groundwater provide the source of most drinking water for Canadians. Bottled water may not be a useful answer, since few sources remain which are uncontaminated by toxic chemicals.

In a desirable future, programs would be practical, irresistable to government and would involve a number of powerful institutions in the evolution of program recommendations. Programs need to achieve

legitimacy and support by media, local and provincial governments and key private and non-governmental institutions. These institutions must be convinced that unless action is taken, environmental conditions will deteriorate further and human health will be further endangered. The media will be an essential ally, since one of their major goals is to gain government attention.

In a desirable future, the Great Lakes Basin and the Great Plains Region would receive much more attention. The Great Lakes Water Quality Agreement is currently up for renegotiation and the Inquiry could make an important impact on its final form. The Agreement is a critically important political agreement between the two countries and involves re-convincing both governments to renew their commitments to water quality in the Great Lakes. Despite the past Agreements, however, water quality is deteriorating. More research is needed, information must be more openly shared, institutions must be improved and legislation must be updated.

An ideal future might involve a Great Lakes Celebration for example, in which an image of this great inland sea would be created in the minds of millions of Canadians and Americans. It would be an opportunity for people in the Great Lakes Basin to talk across their borders with each other, to discover the region in a holistic way, to develop channels (radio and television) for people to talk to each other about the future of the region. Cities could be twinned, and

organizations and institutions would exchange information about their shared water heritage. It could be launched with a giant water-based exchange in which yacht clubs, boating organizations, training ships and the like would take the lead to begin the exploratory process. Over five years, organizational development could take place with travelling exhibits, mass information and participation programs. The overall goal would be to resolve and revolutionize waste disposal habits in the Great Lakes Region, to clean up drinking water and to make people aware of their water system as they are now aware of the land on which they live.

An organization called Great Lakes United, involving one hundred voluntarily linked groups in the Great Lakes Basin, is at work on large-scale questions of this sort. They have generated learning groups involving all ages and are now working on a plan to obtain social and political expression.

An example is the Qu'Appelle project in Saskatchewan, in which the five lakes in central Saskatchewan have become the focus of attention. They are seriously polluted, but remain the favoured vacation resort area in southern Saskatchewan. A citizen's group has organized to involve all stakeholders - farmers, local Indian leaders, municipalities, tourist operators - to clean up pollution sources and to bring about a new consciousness about the necessity for higher water quality. A similar organization is being set up in the Red River

Basin to involve as many stakeholders as possible.

The Centre for the Great Lakes was organized two years ago at a conference on the Great Lake Basin. it is independently funded and is intended to examine resource and development issues in the Great Lakes. The goal is to achieve new commitment and awareness of the water system, using research and public participation programs. The lakes are perceived as underpinning future economic growth in the region, but to the surprise of the Centre, the Great Lakes seem to have been largely ignored by key decisionmakers such as local industrialists, mayors, legislators and governors. Initial funding has been obtained from foundations, but more funding is needed at a national level and Inquiry support could be valuable. Individual assistance to the Centre might be expanded if donations could be deducted for tax purposes.

The desirable future will require both mass and independent action as well as regulation and legislation to support the cleanup of critical areas. Legislation and regulation await public education and consultation but could move ahead quickly with government support. When this has been done, governments should continue their efforts by facilitating and nurturing private group action, but should not try to control such supportive action.

To achieve the desirable future will not be easy. Ontario Waste

Management Corporation (OWMC) has attempted to present its case to the public and to solicit public input at each step in the process of selecting a site for processing toxic wastes. However, it is opposed by the tourism lobby, despite the fact that successful toxic processing would lead to cleaner water and ultimately, a stronger tourist industry. The Inquiry will need to take its case to all media in both the United States and Canada, to obtain major coverage on talk shows, to lobby with key institutions. Environmental pressure will be needed if change is to occur.

3. CONSTRAINTS, OPPORTUNITIES AND RECOMMENDATIONS

The final session of the workshop focussed on identifying key constraints on the Inquiry, opportunities to deal effectively with them, and recommendations for action. It proved to be difficult to keep these three categories separate and the discussion of constraints, opportunities and the nature of necessary action often occurred concurrently. The following pages are not therefore as neatly divided as one might hope.

A constraint on public participation with the Inquiry has been a lack of information about the role of the Inquiry, its mandate and objectives. It has not been entirely clear whether the Inquiry is intended to collect information, consult with the community or prepare a report for ingestion by the community. It was agreed that it should attempt to do all three.

A constraint on the widespread publication of water and environmental materials is that a market has not been created. Most people need to be alerted to the existence of issues in the society (racism, multiculturalism, equal opportunity, etc.). To a great extent, government fosters and the media and school curricula reflect the awakening of the public to such issues. The Department of the Environment (D.O.E.) has not been effective in fostering the necessary awakening of the Canadian public to water and environmental issues.

No long-term plan exists for information about inland waters. There is no evaluation of the usefulness of the information programs which exist. There is no money for more systematic programs. Existing programs are divided among many branches and between Ottawa and the regions. Budgets are similarly divided, and no rationale exists for the present budget division. Budgets for information are very low; less than one percent (1%) ($6 million per year out of a total budget of $800 millions per year) of the Department of the Environment's overall budget. Crisis management has dominated activities at D.O.E.

Opportunities and recommendations became indistinguishable in the final stages of the discussion and are reproduced more or less as they were transcribed.

The Commission should show clearly the global water frame which surrounds the continental and Canadian situation. The greenhouse effect, the trade-offs between world food production and water use, the rapid growth in global and continental population and the implications for water resources should be set out in a clear and simple manner.

The Canadian water situation should then be set out in detail, with forecasts until 2025 or 2050. Scenarios with respect to continental population shifts should be outlined, regional pressure points identified, (British Columbia, High Plains, Southwestern United

States, Great Lakes Basin). Water supply-and-use maps should be provided; principles and guidelines defined for water-short regions and the reader should be projected forward from his present water-use pattern to his probable water consumption patterns past the year 2000, if nothing is done. The potential health effects of increasing levels of toxic materials in the water supply should be set out clearly and simply.

The report must not only communicate to the Minister and the provincial Ministers, but to special-interest audiences (farmers, industry, educators, non-governmental organizations, media). Separate documents (texts, "fast-food" documents, cartoons, etc.) should be prepared to offer the same message in other forms to audiences such as "average Canadians" and school children. Interest and trust developed at the point of release and during the follow-up period will determine the long-term value of the Inquiry. Key groups should be brought together at the time the report is released to plan follow-up so that action begins immediately. Environment Canada should take the initiative to ensure that this occurs.

If the Inquiry is to result in the evolution of a new ethic with respect to water, it is important that careful planning for the release of the report should take place now. The Inquiry should decide how the public awareness program is to be carried out and who should do it. Participaction might be a suitable model, since it was also a program

directed to the individual and his/her behaviour. The environmental message must be: "We have serious water problems facing us in the future. I can take daily action to clean up and conserve water. This is how I can do it." This helps the individual to make a positive contribution and to develop a sense of accomplishment by doing so.

The second objective of the Inquiry should be to develop action by major polluters and water users. Industries and farms need facts about the consequences of their present water-use actions. Conservation authorities should be assisted and encouraged to strengthen education and participation activities. Demonstrations should show how the individual interacts with the water system throughout his life cycle. He should be reminded that eighty percent (80%) of his body weight consists of water, which leaves in his system most of the heavy metals and chemical contaminants which he ingests with it. The report should assist the individual to compare his/her behaviour against that of others, with respect to personal habits, household systems, community systems, watershed systems, and the national system.

The report should talk about risk management. People live not by profit maximization but by personal risk management. They prefer a zero risk from hazardous wastes and from their water supply. Toxics in water are not all identifiable nor recognized and while the citizen is unaware of the invisible risks in water, he is being reminded by the media that new risks are being added daily which are beyond the ability

of science and mathematics to calculate. He will look to the Inquiry and after it work is done, to government for guidance on what should be done.

The Inquiry should recommend the establishment of methods for assessing water-using or water-contaminating home products for their impact. The process should not be more difficult than calculating energy use and would allow the householder to select the least-polluting and least water-using appliances and systems for the home and business.

The Inquiry should examine D.O.E.'s role in public information, education and public participation in the water area. Present weaknesses should be identified and recommendations made to ensure that D.O.E. has the resources necessary to establish water research, monitoring and public information at the top of its list of priorities. The acid rain situation proves that D.O.E. can handle topical issues effectively. Similar resources and priority should be given to water supply and pollution abatement.

The Inquiry should examine the relationship between D.O.E. and the provincial and municipal governments which have constitutional and operational responsibility for water. A process for developing public consensus on action should be developed, to involve all levels and involving input from all key stakeholders. If symbolic presence is

needed to set the context for a national program of water-use and water cleanup, should it be the Federal Cabinet itself, rather than D.O.E.? It is essential that water and environmental issues take precedence over financial issues and the departments that represent them in the Federal Government.

In its relationship to the provinces, D.O.E. should be "first among equals" in sharing information, providing a court of last resort if provincial agreement is not possible and in taking action on long-term planning and in the resolution of crises.

Research was discussed at length. Much more is needed, but the group was not sure how it should be co-ordinated. Specific responsibility for watersheds should remain at the regional level. Shared responsibility should involve centrally established standards (D.O.E.); regional management (provinces) and local implementation (the evolution of a low-use, no-pollution ethic with supporting water-use practices, backed up by regulation).

Funding a national water program of this kind may require a federal tax on water use. It was observed that water is so cheap that most people have no idea what it costs and have no conservation ethic (as they do with electicity, oil, natural gas, or gasoline). A national funding base would support the national programs identified here and would permit funding regional and local initiatives. It might

be desirable to create some kind of National Water Commission if it is not possible to bring D.O.E. to the point of view discussed above.

A National Water Commission could follow up the Inquiry in an effective way, to develop uniform data collection standards and a national water data bank; to work with all stakeholders in the national water system, (provinces, watershed authorities, industries, farm organizations, consumers), to develop a climate of awareness, consultation, trust and joint action by informed Canadians to ensure that the findings of the Inquiry will be implemented and that Canadians are kept in touch with the water which surrounds them and the decisions which must be made to keep it abundant and clean.

7. CONCLUSIONS

Work on this project had to be completed in just seven weeks from the granting of the contract until the completion date. It was therefore impossible to conduct any original research. Instead, a number of intensive interviews were conducted, available materials were collected and the Background Document for the search conference was assembled. In this process, it was discovered that an enormous literature exists on public information and participation processes in the United States and Canada for the period 1970 to 1984. Despite the abundance of the literature, very little research has been done to evaluate public information and public participation programs. Their range and variety, coupled with the need to fit them specifically to individual circumstances, makes them uniquely difficult to evaluate. Nevertheless, it is clearly time that greater effort was made to systematically evaluate such programs on a regular basis.

Environment Canada now spends an estimated $6 millions per year out of an annual budget of $800 millions on public information and public participation. I could not find any evidence of systematic and routine evaluation of these programs to determine their effect and value. In general, it appears that the programs have been quite effective in raising public consciousness about environmental issues such as acid rain, the preservation and conservation of natural resources, the evolution of the Parks Canada network, etc. In other

cases, the evidence is less clear that an effective and co-ordinated job is being done.

There is also evidence that the budget of $6 millions, or less than 1% of the departmental budget, is inadequate in view of the intense public concern about environmental issues. If public participation is seen as a window through which the people may influence the development of future envionmental programs, if it is seen as a means by which environmental policies can be developed and as a key element in co-ordinating environmental activities of citizens, industrial leaders, provincial and federal governments, then the budget is far too low. It may be that an expanded public participation budget is the key to lower long-term costs, if it will lead to widespread public understanding of and support for progressive environmental policies.

It appears that many Canadians lack reliable information on which to base their actions, as they attempt to contribute to a cleaner environment. They need better product information about the effects of individual items (auto exhaust emissions, furnace burner emissions, etc.) in order to select the cleanest products. They need better information about the toxic products they use and proper disposal methods. They need more information about toxic elements in their water supply and possible measures which might be taken. They need a "State of the Environment" report from government at regular intervals

to provide a sense of progress (or lack of progress) in the search for a cleaner environment. They need reliable data on water and air quality and the causes of deterioration in quality, so they can make decisions about agricultural practices, industrial location, process design, equipment selection, and the like. They need an economic system which rewards the user of cleaner products and punishes the user of polluting products.

With respect to water resource issues specifically, it is difficult for Canadians to obtain information about the long-term water demand and supply picture for specific areas of the country (Prairies, Northern Canada, Central Ontario, etc.). There has been little effort to connect long-term continental population changes with long-term water supply and demand, so individual Canadians lack a clear picture of the water system and the areas where changes in policies and practices will be required.

Through the efforts of such institutions as the Canada Centre for Inland Waters, the Great Lakes Region and environmental issues generally are much better known and understood. However, the information often reaches the public as "scare headlines", instead of in a more thorough and orderly fashion. This in turn helps to cause the crises with which Environment Canada seems to be occupied most of the time.

Since early in 1984, a new series of high level "consultative processes" have been undertaken by Environment Canada, involving senior provincial environmental officials, industrial and labour leaders and academics. These processes are achieving consensus on action to reduce water and air pollution at source. Task Forces are currently at work on specific steps required to deal with toxic wastes, to develop a sound data base, to develop a "state of the environment" report and to develop a working basis for industry, labour and government collaboration on the environment. Although it is too soon to evaluate these "consultative processes", it may be that this is the prototype for expanded public participation processes of the future, involving municipal, voluntary organization and media leaders who in turn could extend the process.

The development of institutions such as Pollution Probe, the Centre for the Great Lakes, the Great Lakes Institute, etc. indicates that citizen interest is growing, not abating. It is essential that Environment Canada take the lead in providing reliable material for these organizations, together with support for information and public participation processes which they will undertake.

8. RECOMMENDATIONS

1. That the Federal Department of the Environment develop a reliable and trustworthy data base on the environment (water and air quality, etc.) and make it widely available for public use.

2. That the D.O.E. publish a State of the Environment report at least biennially, to provide a benchmark for all citizens on the progress being made toward a cleaner environment.

3. That D.O.E. further support and develop a wide range of "consultative processes" to involve all levels of government, industry, labour and academics, non-governmental organizations and citizen leaders in the evolution of efforts leading to a cleaner environment.

4. That D.O.E. conduct a systematic evaluation of its public information and public participation programs to determine which are most useful and to focus resources on these programs.

5. That D.O.E. argue for the necessary resources for a much-expanded public information and public participation process, centred on the most effective and useful programs.

6. That a National Water Commission or National Water Council be

created to represent all major stakeholders in the national water system. The Commission or Council should have the following responsibilities:

a. to implement the measures recommended by the Inquiry on Federal Water Policy.

b. to develop a long-term (30 to 50 years) perspective, data bank and plan for water use in Canada. This should include forecasts of population growth, demand, supply and quality of surface and groundwater in Canada, and should outline the long-term implications for consumers, agriculture and industry and short-term policy and program implications.

c. to develop public information and public participation programs to ensure that every Canadian understands water supply, demand and quality issues and is able to make rational and constructive personal, corporate and institutional choices, which will in the aggregate, lead to desirable policy outcomes.

d. to assist in the development of a public understanding of the key watersheds in Canada, including the Great Lakes, the High Plains, the Pacific Region and the North (Mackenzie); their vulnerability and private and public measures required to ensure a sustainable water environment.

e. to work closely with all levels of government (D.O.E., provinces, municipalities) to ensure that water-related public information and participation programs are

consistent, properly organized and managed and that a proper balance is maintained between "top-down" and "bottom-up" programs.

f. to evaluate public information and participation programs of various levels of government relating to water and to suggest improvements.

QUOTES

1. National Water Commission, National Technical Information Service, Springfield, Va., 1972, p. 373

2. Warner, Katherine P., "Public Participation in Water Resources Planning", prepared for the National Water Commision, National Technical Information Service, Springfield, Va., pp. 127-129

3. Ibid., p. 374

4. Delli Priscoli, J., "Beyond Public Hearings: Suggestive Techniques for Public Participation in a Transnational Resource Management Environment", Ann Arbor, Michigan, June 23-24, 1975, p. 54

5. Ibid., p. 57

6. Ibid., p. 61

7. Ibid., p. 64

8. Huntington, Samuel,"Paradigms of American Politics: Beyond the One, Two and the Many", Pol. Sci. Quarterly, Vol. 89, No. 1, March, 1974, p 22.

9. Environment Canada Challenges Update:The Environmental Agenda, Canadian Trend Report, Montreal, October, 1984.

PARTICIPANT LIST

1.	Francoise Bertrand, Commission, Inquiry on Federal Water Policy, 3255 Queen Mary Road, Apt. #524, Montreal, P.Q., H2V 1A5.	(514) 282-3053 (o) 739-7462 (h)
2.	Elizabeth Dowsdeswell, Inquiry on Federal Water Policy, 6th Floor, 240 Bank Street, Ottawa, Ontario, K1A 1C7.	(613) 993-6551
3.	Charles Fremes, Decima Quarterly Reports, 3080 Yonge Street, Suite 4022, Toronto, Ontario, M4N 2K4.	(416) 481-5123
4.	Kai Millyard, Pollution Probe, 12 Madison Avenue, Toronto, Ontario, M5R 2S1.	(416) 926-9876
5.	Beatrice Olivastri, National Survival Institute, 27 - 53 Queen Street, Ottawa, Ontario, K1P 5C5.	(613) 232-6634
6.	James McLaren, Commission, Inquiry on Federal Water Policy, 2 Bloor Street East, Suite 2612, Toronto, Ontario, M4W 1A8.	(416) 924-4827
7.	Michael Scott, Director of Communications, Ontario Waste Management Corporation, 2 Bloor Street West, Toronto, Ontario, M4W 3E2.	(416) 923-2318

8. Cathy Starrs,
Corporate Planning Group,
Environment Canada,
10 Wellington Street,
Hull, P.Q.,
K1A 1C7.

9. Gail Stewart, (613) 235-2796
141 Cameron Avenue,
Ottawa, Ontario,
K1S 0X2.

10. Gail Turner, (819) 994-1410
Community Relations Officer,
Information Directorate,
27 Floor,
Les Terrasses de Chaudiere,
10 Wellington Street,
Hull, P.Q.,
K1A 0H3.

11. Dana Vindasius, (819) 997-1897
Socio-Psychological Advisor,
Socio-Economic Division,
Water Policy and Management Branch,
Inland Waters Directorate,
Environmental Conservation Service,
Environment Canada,
Ottawa, Ontario,
K1A 0E7.

12. Linda Weigl, (306) 569-0766
President,
Weigl Educational Publishers,
2114 College Avenue,
Regina, Saskatchewan,
S4P 1E5.

13. Donna Wise, (312) 645-0901
President,
Centre for the Great Lakes,
Suite 1733,
435 North Michigan Avenue,
Chicago, Ill.,
U.S.A.,
60611.

14. Rodger Schwass, (416) 233-6386
Conference Facilitator,
71 The Kingsway,
Toronto, Ontario,
M8X 2T3.

INDEX

1. Clippings

2. Gail Stewart, Gaining Perspective on Environmental Issues: A Fresh Look at Familiar Problems.

3. Canadian Trend Report, October, 1984, Environment Canada: The Environmental Agenda.

4. Canadian Trend Report, June, 1984, Public Opinion Surveys and the Environment.

5. L. Wheeler, F.E.S., Contrasting the Rational-Comprehensive and Learning Models of Planning, 1985.

6. Barry Sadler, Andrew Thompson, Towards new Strategies of Public Involvement in Environmental Management.

7. Jerry Delli Priscoli, Beyond Public Hearings.

8. G.M. Farrell, J.P. Melin, S.R. Stacey, Involvement: A Saskatchewan Perspective.

9. James V. Marks, Vetting Long-Range Planning Options With The Public: The Case of the South Saskatchewan River Basin Planning Program.

10. Robert Rosehart, Policy For Public Consultation and Information Availability for Environmental Protection Service, 1982.

11. Environment Canada, Questions and Answers About the Consultative Policy.

12. Supply and Services Canada, Public Awareness Programs for Science and Technology.

13. Environment Canada, Western and Northern Region Working Group, September, 1984.

14. Environment Canada, Report of Workshop on Water Issues.

15. P.H. Pearse: Turning the Tide: A New Policy For Canada's Pacific Fisheries, 1982.

16. Hal Mills: Recommendations For Task Force On Northern Conservation, September, 1984.

17. Briefs to Inquiry on Federal Water Policy:

- Mark B. Stagg
- A.C.E.S.
- Union of Ontario Indians
- J.B. Carson: The Use of Schools in the Development of Water Policy.
- Arthur News: The Prairie Association of Water Management.
- Parks Canada: Co-operating Association Program.
- Slave River: Development Impact Zone Society Basin Coalition.

APPENDIX 3

Terms of Reference

Objective

The Inquiry on Federal Water Policy, established by the federal Minister of the Environment, has approved the following undertakings by Canadian International Consulting Economists focussed on a project "Public Information and Consultation in Water Management".

Tasks

1. Assembly of relevant surveys, recent papers, etc., and preparation of a background document which sets out key issues and recent experience in Canada and other countries concerning public participation in policy development and environmental issues.

2. Review and evaluation of federal government provisions for public information and consultation on matters relating to water management, including consultants, advisory groups, and publication sponsored by various agencies.

3. Organization of a small workshop involving 10 to 12 experts who would interact with Inquiry members in considering different scenarios and building an appropriate policy.

4. Recommendation of feasible policies and programs which could be adopted or expanded to improve public awareness, understanding and participation.

Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

Research Papers

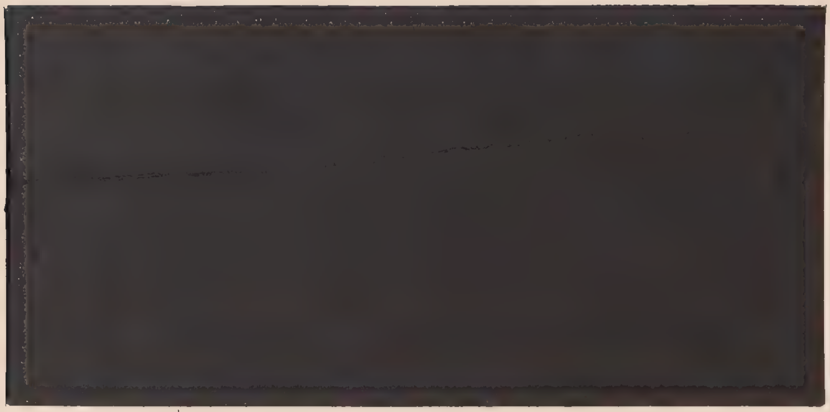
Documents de recherche

WATER IN CANADIAN HISTORY: An Overview

by

Peter Gossage

Canada



Inquiry on Federal Water Policy
Research Paper # 11

WATER IN CANADIAN HISTORY:
An Overview

by

Peter Gossage

March 1985
Département d'histoire
Université du Québec à Montréal

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn

Frank Quinn
Director of Research

Abstract

This research paper treats the history of water, the use and development in Canada from earliest times until roughly 1960. The discussion is organized into seven sections. The first six sections correspond to specific historical periods, and attention is focused mainly on the increasingly complex relationship between human societies and their water environment in northern North America. A brief outline of some of the geological forces which shaped that environment is followed by sections treating the importance of water to Native peoples, to Canada's earliest explorers and traders, to the first European settlers in the seventeenth and eighteenth centuries, to the expanding agricultural and industrial communities of the nineteenth century, and to twentieth-century Canadian society. The final section shifts attention to the role of the Federal government in the development and management of the water resource in the period from 1850 to about 1930.

Résumé

Ce rapport traite de l'histoire de l'eau au Canada, de son utilisation et de son développement des temps les plus anciens jusqu'à 1960 approximativement. Le rapport est divisé en sept sections. Les six premières sections correspondent à des périodes spécifiques de l'histoire et l'attention est principalement portée sur la relation de plus en plus complexe entre les sociétés humaines et leur environnement hydrique dans le nord de l'Amérique du nord. Un bref profil de quelques-unes des forces géologiques qui ont généré cet environnement est suivi de sections traitant de l'importance de l'eau pour les peuples autochtones, pour les premiers explorateurs et négotiants du Canada, pour les premiers colons venus d'Europe au dix-septième et dix-huitième siècle, pour les communautés agricoles et industrielles en expansion du dix-neuvième siècle et pour la société canadienne du vingtième siècle. La dernière section porte sur le rôle du gouvernement fédéral dans le développement et la gestion des ressources en eau durant la période de 1850 à 1930 environ.

CONTENTS

Introduction

Water has played a fundamental role in the development of Canadian society. It is therefore useful to examine the changing nature of the relationship between human beings and the water environment of northern North America through history.

Canadian society developed in a number of distinct phases, corresponding more closely to stages of economic and technological development than to changes in constitutional structure. Accordingly, the main body of this report is divided into six sections, each corresponding to an historical period characterized by one or more distinct developments. A final section is devoted to political and administrative aspects of water development, and more specifically to the role of the federal government in the period from the 1850s to the 1930s. The contents of these seven sections will now be outlined briefly.

Retreating Glaciers

The first section will cover the period from about 20,000 B.P. (before the present) to about 6,000 B.P.: roughly the period of the retreat of the last great glacier to cover northern North America. This enormously significant geological event set the stage for the development of human societies in Canada. It went a long way toward determining the character of the physical environment -- and particularly

the water environment -- to which humans would later adapt.

Native Societies

As the glacier receded, Native societies developed in all regions of Canada. These distinct cultures made many successful adaptations to what was often a very watery environment. In the second section, I will look at Native peoples prior to European contact, in terms of how they used and regarded water.

Exploration and Early Trade

In the third section, attention will be focused on the initial phase of European contact with North America. This period, which began in either 1000 or in 1497 (depending on the stress one wishes to place on the Norse expeditions of the eleventh century), was characterized by two types of activity on the part of the Europeans: exploration, and trade with the Natives. Water routes were essential to both of these activities. Explorers' accounts can usefully be consulted as a means of gauging the Europeans' impressions of the 'New World' and its water resources, and as documentation for the origins of trade.

Settlement and Expansion

With the establishment of Québec by Champlain in 1608, the settlement phase of Canadian history can be said to have begun. Québec was not the first French outpost in North America,

but it was the first to develop into a permanent population center. The years from 1608 to 1800 saw the growth of the French agricultural colony on the St. Lawrence, as well as the emergence of important settlements in the Maritimes. They were also characterized by the growth of the fur trade into the central commercial activity of the continent. This implied the westward and northward extension of trade routes, and the discovery of new territories and water systems lying to the west.

The Nineteenth Century

The fifth section will treat the nineteenth century. In Canada, this period was characterized by population increase, westward expansion, urbanization, industrialization and political consolidation. It saw the emergence of many new industries based on water power, new cities requiring water supply, a revolution in transportation and the extension of the agricultural frontier. As eastern cities grew, more and more urban dwellers felt the need for fresh air and clean water, and the recreation potential of Canada's water resource was first realized. Quite early in the century, logging emerged as one of Canada's most important industries, particularly in Ontario, Quebec and New Brunswick. Canals were dug and later deepened all along the St. Lawrence system to facilitate communications and trade between the Great Lakes and tidewater. The steam engine emerged in both transportation and industry and played a major role in Canada's industrial revolution.

The expansion of settlement and trade into the prairie region and British Columbia was another important development of the nineteenth century.

The Twentieth Century

Canadian society had become even more complex by the beginning of the twentieth century. In one sense, if the nineteenth century was the age of coal and steam, the twentieth is that of hydroelectric power. Major projects -- intended not only to produce power, but to provide improved navigation, water storage and flood control -- were proposed and implemented on water courses all over the country between 1900 and 1960. In a real sense, Canadians no longer sought to adapt to their water environment: they sought to adapt that environment to their expanded needs. Along with the increased scale and complexity of water use came conflicts between potential uses and users. Often these conflicts took place across municipal, provincial and international boundaries. The emergence of interjurisdictional agencies to deal with this type of problem should be seen in this context. Problems associated with water pollution can also be attributed to the expansion in the variety and extent of water uses in the twentieth century, although some of these problems were already apparent to observers in the nineteenth.

The Federal Role

The seventh section will turn away from primarily social

and economic considerations, and focus on political and administrative aspects of water development. Emphasis here is squarely on federal agencies which played a role in managing water resources, and on the policies they adopted and implemented. The periodization used here is distinct from that adopted for the rest of the paper. Events which occurred in the 1850s are considered along with some which occurred as late as the 1930s. This departure was deemed necessary because the evolving federal role in water development is a topic which pertains to both the nineteenth and the twentieth centuries, and which could not be treated effectively in either section five or section six.

Section 1: Retreating Glaciers

Water played a crucial role in Canada's pre-history. Long before the Norse excursions of the eleventh century, perhaps even before the proto-Amerindian peoples crossed the Bering Strait, huge ice-sheets advanced and receded over northern North America, shaping its environment and establishing the context for the development of human societies in this country.

Over the last million years or so, continental glaciers as much as two miles thick have invaded Canada several times In terms of its effects on the current Canadian landscape, the most recent glaciation -- known as the Wisconsin -- is the most significant.

The Wisconsin ice-sheet reached its maximum extent something like 18,000 to 20,000 years ago. At that time, Canada was almost completely covered with ice, except for an ice-free corridor east of the Cordillera stretching from Alaska to the American Northwest. This corridor may have accommodated migrating hunters from Asia at various stages of the glacial era. From this point forward, the ice gradually began to melt: a process which was occasionally interrupted or reversed as the earth's temperature cooled down temporarily. By six to seven thousand years before the present, however, Canada was virtually ice free, except for the Baffin-Ellesmere region and certain parts of the West.

The action of this most recent glacier fundamentally altered the physical environment of northern North America. As it receded, the territory which is now Canada became "a vast storehouse of fresh water, including some of the largest lakes ever to have existed in North America."[1] In mountainous areas, glacial erosion scoured basins out of hillsides; these filled with glacial melt-water to form tarns. Glacial sediments were deposited over melting stagnant ice in the Canadian Shield, giving it the rugged landscape covered in lakes and streams we know today. And broad, low-lying areas such as the Great Lakes basins were further deepened and smoothed as glacial activity excavated the softer rocks they contained.[2]

In terms of geological time, Canada's vast system of lakes and rivers is a relatively recent arrival. One glaciologist points out the effectiveness of glacial action on water networks, suggesting that

> Few lakes within the boundaries of the ice age glaciations originated earlier than the Wisconsin glaciation . . . . In fact, a good approximation of the southern limit of the Laurentide ice sheet during its last advance in the midcontinent is a line separating areas where lakes are abundant from those where no lakes exist.[3]

Canada, of course, lies entirely above such a line. Another authority states a similar case with specific reference to Canada:

> The retreat of the ice added new features to the land surface. The indiscriminately scattered morainic debris caused widespread interruption of drainage, resulting in a fantastically intricate pattern of lakes,

> large and small. The constant flow of melt water . . . left its own marks in valley trains, outwash aprons and channels . . . .[4]

These geological events of the late Pleistocene are important in historical terms because they constitute the creation of Canada's water environment. Two specific incidents in the pre-history of Canadian water are the rise and decline of Glacial Lake Agassiz -- named for an early exponent of the ice-age theory -- and the evolution of the Great Lakes system. These can be discussed briefly before attention is turned to the importance of water to Canada's earliest inhabitants.

Glacial Lake Agassiz -- on whose Manitoban shorelines, artifacts of early human settlements have been found -- began forming about 12,000 years ago when glacial melt passed an important topographical divide in western Minnesota. At its full extent, it covered 350,000 square kilometers of territory in Minnesota, the Dakotas, Saskatchewan, Manitoba and Ontario, with a maximum depth of some 200 meters. The lake, which completely covered the southern part of Manitoba, lost most of its water about 8,000 years ago. Today, its vast bed constitutes some of the richest agricultural land in Canada. Many of Manitoba's water-ways, including Lake of the Woods, Lake Winnipeg and Lake Winnipegosis, are shallow remnants of Glacial Lake Agassiz.[5]

The Great Lakes system, which is such a central axis in Canadian history, did not develop its current hydrological configuration until perhaps as recently as 2,000 years ago. According to geologist J.L. Hough, Lake Michigan's waters

still drained southward via the Rivière des Plaines and the Mississippi system at that time.[6]

In fact, the development of the Great-Lakes drainage system went through a number of stages as the last great ice sheet receded. In the first stage of the retreat of the Wisconsin glacier, "pro-glacial lakes" formed as melt water gathered between ice fronts and heights of land. All of the pro-glacial Great Lakes initially drained southward via the Mississippi, because their eventual eastward trajectories were still blocked by ice. In a second stage of de-glaciation, the Great Lakes expanded, taking on more or less their present-day forms. At this stage, however, sea levels were much higher than today; the Champlain Sea covered most of the St. Lawrence Valley; and the upper Great Lakes flowed eastward into the Champlain Sea via rivers such as the Trent and the Ottawa. It was only in the final stage of the Wisconcin de-glaciation that the Great Lakes - St. Lawrence system assumed its current configuration. In geological terms, these are very recent events indeed.

What is the significance of these earlier lake stages to the subsequent development of water-transport in Canada? They might be related to two separate eras in history: that of canoe-travel and that of canal building. Hough suggests first of all that,

> The Ottawa - Mattawa - French Rivers route was navigable for canoe travel because of its geologic history; it was at one time the outlet for drainage of the three upper Great Lakes. Likewise, the route from

> south-eastern Georgian Bay to Lake Ontario, and the Route from Lake Michigan to the Illinois River, were amenable to canoe travel because they were former discharge-ways of the three upper lakes.[7]

With respect to canals, he argues that those,

> . . . of the Mohawk Valley - Lake Erie, the Georgian Bay - Lake Ontario, and the Lake Michigan - Illinois River routes were economically feasible because they were placed in natural valleys which, at one time or another, were former dischargeways of the Great Lakes.[8]

The events of the Wisconsin glaciation, then, had important effects on Canada's physical environment. Lakes and rivers were born as glacial ice first scoured the landscape and then deposited sediments and melt water in its wake. Drainage systems evolved over a period of thousands of years, and did not assume their current configuration until relatively recently. These events helped define the character of the land and water environment to which Canadian societies would later adapt.

Notes to Section 1

1. C.L. Matsch, North America and the Great Ice Age (New York: McGraw-Hill, 1976) p. 88.

2. Ibid., pp. 88-9.

3. Ibid., p. 88.

4. J. Warkentin (ed.), Canada: A Geographical Interpretation, p. 17.

5. Matsch, p. 90. See also W.J. Mayer-Oakes (ed.), Life, Land and Water. Proceedings of the 1966 Conference on Environmental Studies of the Glacial Lake Agassiz Region (Winnipeg: University of Manitoba Press, 1966)

6. Cited in J.C. LaSerre, Le Saint-Laurent: grande porte de l'Amérique (Montréal: Editions Hurtubise HMH, 1980) p. 38.

7. J.L. Hough, "The Prehistoric Great Lakes of North America," in American Scientist 51 (1963) p. 85.

8. Ibid., pp. 86-7. Some of these former spillways have been re-opened in inter-basin water-transfer projects, such as the south Saskatchewan to Qu'Appelle River diversion.

Section 2:
Native Societies

The first appearance of human beings in a North American context is a much debated issue. Most scholars now agree that the first Americans probably crossed the Bering land bridge at a point when sea levels were much lower than today. But the timing of this event remains uncertain.

One recent text-book in Canadian human geography gives 15,000 to 25,000 years before the present as the best estimate of the first arrival of human beings in Canada. Its authors suggest that the earliest North Americans possessed a very simple culture based on hunting, gathering and fishing. Archaeological evidence from the late Pleistocene establishes the presence of human settlements in the Maritimes, along the shorelines of pro-glacial lakes, and in the ice-free corridor east of the Cordillera.[1]

Five thousand years ago, Canada was physically much as it is today. It was populated, however, by a series of nomadic and semi-nomadic peoples who made remarkable adaptations to diverse but always demanding environments. The need for water was common to all these cultures, as it is to human societies everywhere. Natives needed water to drink and for cooking, as a medium of transportation and in agriculture. Water supplied the habitat for fish and water-fowl which provided food, and for beaver and other fur-bearing creatures which provided skins for warmth in winter. Watersheds were among the few territorial boundaries between tribes, and

fish and other water animals played an important part in the Natives' animistic religions. Except for the plains of the southwest and the more mountainous areas, early Canada was a "watery land."[2] Much of the social, economic and political life of its first inhabitants depended on access to water.

We can divide our look at water in Native society into several areas. Food -- including fishing, hunting, gathering and agriculture -- was obviously of critical importance. Transportation -- whether for purposes of migration, trade, hunting or fishing -- was only slightly less crucial. After considering these two areas, the political and religious significance of water in Native society can be examined.

Food

Early societies expended a high proportion of their time and energy securing food to ensure their survival. In Canada, water played an important role at many stages of this process. Diet varied a great deal between tribes and cultural groups. Few tribes however did without fish.[3] West Coast peoples were heavily dependent on the salmon runs up British Columbia's rivers for centuries before European contact. Iroquoian groups in the Great Lakes basin supplemented their agricultural economy by fishing for such species as whitefish, trout and sturgeon. And each summer, the hunting tribes of the eastern and northern forests migrated towards fishing-grounds known to them for generations.

Fishing, then, was the most obvious way in which water

helped to support human life in Canada prior to European contact. In various parts of the country, Natives developed more or less elaborate means of catching the fish which inhabited Canada's water courses. Anthropologist Diamond Jenness made an inventory of these techniques in the 1950s, using archaeological and historical evidence. He suggests that in areas of Canada other than the plains,

> . . . the fish-hook and the fish-spear, the net, trap, and weir were as indispensable at certain seasons as the bow and arrow; and dried fish was a staple food in nearly every community during the first two months of winter.[4]

Jacques Cartier, on his second voyage to Canada in 1535 took note of the

> . . . large number of huts along the banks of the (St. Lawrence) river, which are inhabited by Indians, who catch great quantities of the numerous good fish in the river, according to the season.[5]

He was also interested in the techniques used by the Natives to preserve their fish, noting that the Huron

> . . . have in their houses large vessels like puncheons, in which they place their fish, such as eels and others, that are smoked during the summer, and on these they live during the winter.[6]

Though familiar with the use of the barb, Native groups generally avoided its use on fish hooks. For set-lines, a gorge rather than a hook was used; this was a short, sharp, straight piece of wook or bone set inside a piece of meat or fish. Hooks were used for trolling or jigging. Some tribes used the eyes, skin or belly of the fish for bait; others

carved pieces of bone, ivory or stone to act as lures. Indians on both coasts jigged cod, halibut and salmon in bays and inlets; northern Indians and Inuits trolled from their canoes and jigged through the ice for whitefish, salmon and salmon-trout. Eastern tribes often fished at night, using torches and spears to catch sturgeon, salmon and eels. Also using torches, B.C. tribes speared or clubbed salmon swimming upstream; in winter, some groups set lures near holes made in the ice and speared approaching fish.[7]

All of these methods yielded few fish, compared to the vast number caught with nets, traps and weirs. Northern, eastern and west-coast Indians all used the seine, a net placed vertically in the water with floats at the top and weights at the bottom. Eastern and B.C. groups had bag-nets and dip-nets, usually used in conjunction with weirs.[8]

Jenness gives a fair amount of detail where the construction of weirs is concerned. In general, such an undertaking involved the labour of all the members of a community. For certain tribes, the importance of this communal effort cannot be overemphasized. In parts of B.C., for example, log weirs were used to trap fish which accounted for two thirds of the Natives' food supply; their destruction by floods or by enemies therefore meant disaster for a community. Similar barricades, built of piles and brush, were used by Native fishermen in the east. In the north, the Inuit trapped salmon-trout between rows of low dams made of stone. And on Vancouver Island, the Kwakiutl and Salish built U-shaped stone dams along the banks

of tidal rivers to catch salmon.[9]

Fishing, while certainly the method of food-procurement in which water was most clearly involved, was not the only such method. Water-fowl, which were abundant in early Canada, could be hunted with bow and arrow, as could beaver, otter and other water mammals. Beaver meat was probably an important food source for many tribes before Europeans became so interested in its fur. In a large sense, all hunting efforts were grounded on Canada's water resources, since the animals which were hunted needed water themselves in order to survive.

Agriculture is an aspect of Canadian aboriginal society which seldom receives much attention. Iroquoian peoples around Georgian Bay, in the St. Lawrence Valley and South of Lake Ontario grew maize, beans and squash for food, sunflowers for the oil, and tobacco to smoke. Clearly, an adequate supply of water in the form of rainfall was essential if these communities were to thrive -- as they did.

The Hurons are the Iroquoian tribe which have received the most scholarly attention in Canada. Anthropologist Bruce Trigger suggests that among the Huron, agriculture accounted for two thirds of the food eaten. The technology was of a "slash and burn" type in which the men cleared the land by using fire and stone axes to fell trees, and women planted, cared for and harvested the crops. Because of the low level of technology, light and sandy soils which could be worked easily with wooden spades were preferred. Such soils provide

good drainage, but are particularly susceptible to drought, and there was a good deal of anxiety about the possibility of such a disaster in Huron society. Drought or no drought, Huron villages had to be moved every ten to twenty years because of soil depletion; they are therefore generally classified -- with other Iroquoian peoples -- as semi-nomadic.[10]

In addition to hunting, fishing and agriculture, Native peoples gathered the nuts, fruits, berries and herbs that grew wild in their environment. The Ojibwa people, who lived north and west of Lake Superior, had a method for collecting wild rice which was observed by explorer David Thompson in the nineteenth century:

> The wild rice is fully ripe in the early part of September. The natives lay thin birch rind all over the bottom of the canoe, a man lightly clothed or naked places himself in the middle of the canoe, and with a hand on each side, siezes the stalks and knocks the ears of rice against the inside of the canoe . . . . so plentiful is the rice, an industrious man may fill his canoe three times in a day.[11]

Water was also used, in all native cultures, in cooking and as a beverage.

Transportation

Most Native tribes in Canada were essentially nomadic. Travel could be undertaken in one of two ways: on foot or on water. There were no roads and no wheeled vehicles, and the only draught animal was the dog. Rivers, lakes and streams served as important transportation links in both winter and summer. Surfaces which could be paddled across in warm

weather could be tramped across on snowshoes in cold. This ability to travel over Canada's water courses was essential to hunting, fishing, trade and warfare in Native Canadian society.

The canoe, of course, is a singular example of Native peoples' ability to adapt to their water environment. Indian canoes were of two main types: the dugout, which was carved from a single log, and the ribbed craft covered in bark or hide. Dugouts prevailed on the Pacific coast and among certain Iroquoian peoples in the east. Bark canoes -- which were light, easily repaired if comparatively frail, and which could be portaged across low watersheds without difficulty -- predominated in eastern Canada and in the Mackenzie basin. Birch was the preferred material for the outer shell; cedar ribs gave these craft their characteristic shape, and the whole was held together with the roots and gum of the spruce tree. The Inuit, of course, had their own characteristic craft: the kayak and the umiak. Only certain groups on the plains did not build and use boats of one kind or another for transportation.

By most accounts, the birch-bark canoe was the finest of all the craft built by Native Canadians. Though easily damaged, these boats could be repaired using materials commonly found alongside rivers, streams and lakes. Handled skilfully, they were well adapted to the descent of the many rapids on Canadian water-courses. In most cases, they were light enough to be carried by one man if a portage became necessary. The

best birch-bark canoes were those made by members of the Algonkian cultural group. Jenness suggests that the Iroquoian tribes living at the southern extremity of birch country often purchased canoes from the Algonkians, rather than using the heavy pine dugouts or elm-bark canoes they could make themselves. He also points to the importance of the canoe in the subsequent development of the fur trade.[12] G.P. de T. Glazebrook has also paid tribute to the birch canoe in his History of Transportation in Canada, for many years the standard work on the subject. According to Glazebrook,

> The canoe *par excellence* . . . was that made of the bark of the birch tree. This was an Algonquin type of canoe and was made with astonishing skill by the various tribes of the Algonquin family with the crude instruments at their command. Of paper-like thinness, the birch canoe might nevertheless last for some time under careful treatment. It combined speed and carrying capacity with extreme lightness, so that it could be carried -- "portaged" -- past unnavigable sections with comparative ease; and yet it was strong enough to stand the rapids down which it was steered.[13]

Canoe construction varied from tribe to tribe, even within a given cultural group. More substantial differences -- such as those between the bark canoes of the Algonkians and the dugouts of the Pacific Coast Indians -- represent adaptations to distinct environments. The Coastal Indians carved long, narrow dugouts from a single log, usually of cottonwood. Among certain tribes, the Haida for example, this carving could be highly ornamental. These sleek boats -- which were usually poled rather than paddled -- provided stability in the fast

but shallow waters of British Columbia's coastal rivers. Larger craft, these of cedar, were built for communication between the mainland and the islands.[14]

Some attention should be paid to the importance of watercourses as transportation links in winter, since frozen lakes and rivers were among the principal trails followed by the nomadic hunting tribes in winter. Snowshoes greatly facilitated this means of conveyance and seem to have been developed quite early, particularly by Algonkian peoples. Dogs could be harnessed to toboggans in winter and made to haul a reasonably heavy load. The Inuit dog-sled, of course, is the best known example of this type of technology.

Travel in winter was mainly for purposes of the hunt. Game had to be followed into its winter feeding grounds, and this meant seasonal migration for hunting tribes such as the Algonkians. Life was more sedentary for farmers such as the Iroquoians. Still, according to Trigger, Huron men went on long fishing expeditions in their canoes, traded maize for furs with the hunting peoples of the north, regularly visited their hunting grounds, and travelled across Lake Ontario to wage war on the Iroquois. In all cases, water was the basic medium of transportation.[15]

Political & Religious Significance

Many scholars who treat the subject consider Canadian aboriginal political structure to have been fairly loose. Normally, the largest organizational unit was the tribe,

which might consist of fifty, one hundred or two hundred families. Similarities in culture and/or language did not always translate into political affinity, a situation to which the Huron-Iroquois conflict of the seventeenth century (which contributed to the destruction of Huronia around 1650) attests. Internal political structure varied from one cul-trual group to another. Most had some type of kinship -- or 'clan' -- structure; some -- such as certain Pacific Coast groups -- had class systems based on slavery.

In terms of territorial boundaries, Native communities were so spread out that it was mainly with respect to hunting grounds that this could become an issue. One student of the subject suggests that Algonkian tribes claimed something like territorial rights in "fixed tracts of country, the boundaries of which were determined by certain rivers, ridges, lakes or other natural landmarks."[16] This seems to confirm the impression given by Champlain in his account of explorations in the year 1608 when he refers to the Richelieu River as the "River of the Iroquois."[17] The same student goes on to suggest that

> In southeastern Canada, the boundaries between Indian tribes were principally watersheds. They seem to have been continued seaward to prominent coastal features, along general lines continuing the watersheds.[18]

It is beyond question that in Native society, water courses and drainage basins were among the most important geographical features. It is only natural that they should have been used-- whether formally or informally -- to delineate tribal territories.

Finally, water was important in the spiritual life of most native communities. This is not surprising, since life and death could depend on the availability of water and of the plant and animal life it supported. Among the agricultural Hurons were shamans who claimed to be able to control the weather. Some of these shamans

> . . . would predict frost, suggesting at the same time that it could be prevented if the Huron burned a little tobacco each day in their fields to honour the sky. In times of drought, others would promise to produce rain in return for public gifts.[19]

Beyond this, most tribes adhered to a form of animism, which attributed spirituality to most natural phenomena, including wind, rain, rocks, streams, plants and animals. Totemism grew out of animism and ascribed common ancestry to members of a given clan and a particular plant or animal. Water-based animals such as the turtle, the heron, the eel, the beaver and the salmon were among the totem-beings which lent their names to clans in various parts of Canada.[20] This can be taken as another index of the importance of water to Canada's first inhabitants prior to European contact.

Notes to Section 2

1. Warkentin, p. 20.

2. Ibid.

3. Exceptions here are certain Plains Indians who relied primarily on the buffalo.

4. Diamond Jenness, Indians of Canada. National Museum Bulletin no. 65 (Ottawa, 1955) p. 61.

5. H.P. Biggar (ed) The Voyages of Jacques Cartier (Ottawa: Public Archives of Canada, 1924) p. 142.

6. Ibid., p. 158. A puncheon is "a large vat of varying capacity." (Webster's).

7. Jenness, pp. 61-2.

8. Webster's defines a weir as a "fence or enclosure set in a waterway for taking fish."

9. Jenness, p. 64.

10. Bruce Trigger, The Huron: Farmers of the North (New York, 1969) pp. 26-7.

11. Quoted in Jenness, p. 43.

12. Jenness, p. 108.

13. G.P. de T. Glazebrook, A History of Transportation in Canada, Vol. 1 (Toronto: McClelland & Stewart, 1964) p. 2.

14. Jenness, p. 105.

15. Trigger, pp. 20, 30.

16. Norman L. Nicholson, The Boundaries of Canada, its Provinces and Territories (Ottawa: Queen's Printer, 1964), p. 5.

17. H.P. Biggar, (ed.) The Works of Samuel de Champlain Vol. 4, (Toronto: University of Toronto Press, 1971) pp. 74-5.

18. Nicholson, p. 5.

19. Trigger, p. 29.

20. Stanley Ryerson, The Founding of Canada: Beginning to 1815, (Toronto: Progress Books, 1975) pp. 43-45.

Section 3:
First Europeans: Exploration and Early Trade, 1500-1608

The title of this section includes an initial date which has been selected more or less arbitrarily. In fact, it is impossible to say when the first European set foot on what is now Canadian soil, although one can be reasonably sure that it was before the official "voyages of discovery" through which European monarchs sought to expand their influence and their treasuries. Nonetheless, it is primarily to the sixteenth century that the story of early exploration and trade belongs.

Exploration

Perhaps the best candidates for first Europeans in Canada came in ships from Scandinavia via Greenland. The evidence for a Norse presence in Canada in the eleventh century is quite strong. It is of two kinds: literary and archaeological. The literary evidence is familiar to most who have read an introductory Canadian history book. The "Norse Sagas" describe the adventures of Vikings such as Leif Eirikson who sailed westward from the coast of Greenland to discover a land they called 'Markland' -- meaning timberland -- and another they called 'Vinland' after the wild grapes which grew there. Both territories are likely to have been on the eastern coast of North America, although it is very difficult to be more specific.

The best archaeological evidence comes from a site in northern Newfoundland which was excavated in the 1960s. At L'Anse aux Meadows, archaeologists found the ruins of a cluster of houses, boatsheds, and a smithy complete with iron traces, all of a type consistent with Norse culture of the eleventh century. For our purposes, it is interesting (if not surprising) to note that the settlement at L'Anse aux Meadows was located on the banks of a stream.

Many historians have tried to twin the literary with the archaeological evidence. One recent student of the subject suggests that "the published data appear to be sufficient to establish l'Anse aux Meadows with little doubt as a site occupied by the Greenlanders in the eleventh century," and to further identify 'Markland' with Labrador's east coast.[1] A greater mystery surrounds the possible location of 'Vinland', a fertile land occupied by 'Skraelings' who, according to the legends, rode in skin boats, used arrows, and attempted to barter furs for arms. The Eirikson clan made attempts to colonize this land, where in addition to grapes there was excellent grassland for livestock and ". . . no lack of salmon . . . in river or lake, and salmon larger than they had ever seen before."[2]

Water -- albeit salt water -- was of crucial importance to these and all subsequent explorers of Canada, whether Norse, Portugese, Spanish, Italian, English or French. Early explorers of all nationalities had at least one thing in common: they were excellent sailors. Men like Eirikson, Cabot and

Cartier were capable of sailing long distances under difficult conditions through uncharted waters. At least through the seventeenth century, the measurement of longitude at sea was next to impossible, which explains why some of the earliest explorers thought they had reached the east coast of Asia.

Between the eleventh and the late fifteenth century there is little documentary evidence of a European presence in North America. By the latter date, however, the richness of Newfoundland's Grand Banks had become known to fishermen from England, Portugal and other seafaring nations in Europe. Fishing, in fact, was probably the primary motivation behind the "discovery" of Canada. Exploration of the waters on Canada's east coast developed at least in part as a by-product of the fishery.

There were other motives for continued exploration, however. Explorers such as John Cabot -- an Italian mariner sailing under the English flag -- was interested in finding a passage via the northwest to Cathay or, failing that, deposits of gold and silver similar to those unearthed by the Spanish in South and Central America. Cabot's official voyages in 1497 and 1498 yielded more modest results. In 1497, he sighted forests and fire-sites on the shores of what may have been Cape Breton Island, and reported to the king on the richness of the offshore fishery. In 1498, Cabot and most of his crew were drowned at sea in a second attempt to reach the North American coast.[3]

The first official explorer to penetrate any distance

into Canada's interior was Jacques Cartier, who made voyages in 1534, 1535-36 and 1541. Cartier had a lively curiosity and was an interested observer of nature. In the preamble of his report to the king of France, he gave the following summary of what he had seen in North America:

> . . . through the present expedition undertaken at your royal command . . . you will learn and hear of [the] fertility and richness [of the land], of the immense number of peoples living there, of their kindness and peacefulness, and likewise of the richness of the great river, which flows through and waters the midst of these lands of yours, which is without comparison the largest river that is known to have ever been seen.[4]

Cartier's perhaps over-enthusiastic appraisal of the St. Lawrence -- known to him as the River of Canada or of Hochelaga -- may have been influenced to a certain extent by Native accounts of its vastness. One such account was provided to Cartier by the two Indians who had returned to France with him after the voyage of 1534, in their capacity as guides for the voyage of 1535-36:

> The two Indians assured us that this was the way to the mouth of the great river of Hochelaga and the route towards Canada, and that the great river grew narrower as one approached Canada; and also that farther up the water became fresh, and that one could make one's way so far up the river that they had never heard of anyone reaching the head of it.[5]

In 1534, Cartier had only reached Anticosti Island before turning back, so that in 1535-36 most of the St. Lawrence remained to be explored.

Proceeding further up the St. Lawrence, Cartier encountered the mouth of the Saguenay, and recorded the following impressions:

> Some fifteen leagues to the west-south-west of this harbour, in the middle of the stream, lie three islands, and opposite to them there is a very deep and rapid river, which is the river and route to the kingdom and country of the Saguenay, as we were informed by our two savages from Canada. This river issues from between lofty mountains of bare rock with but little soil upon them. Notwithstanding this, a large number of various kinds of trees grow upon this naked rock, in such sort that we saw there a tree tall enough to make a mast for a ship of thirty tons . . . . At the mouth of this river we found four canoes from Canada that had come there to fish for seals and other fish.[6]

Cartier's use of the term 'Canada' in these passages is interesting. He used it as the natives used it or a similar word: to refer to the area along the St. Lawrence bounded by Grosse Island on the east and a point between Québec and Trois Rivières on the west. Like many early topographic and hydrographic names, it later became generalized to denote a much broader area. Other place names have similarly interesting histories. The name Québec, for example, comes from a native word, 'kebec', meaning "where the stream is obstructed:" appropriate since the St. Lawrence, though extremely deep, is only 3,230 feet wide at the site of Quebec City. And the name 'Hochelaga' referred to the region around the Lachine Rapids, and means "at the beaver dam" in the Huron language.[7]

Between the 1540s and the first decade of the seventeenth century, exploration of the Canadian interior and its waterways lagged, although the coastal fishery flourished. The next important explorer of Canada's rivers was Samuel de Champlain, who is generally considered the father of New France, and who spent most of his time between 1603 and the 1630s in Canada. An able geographer, Champlain had been one of the first to propose the building of a canal across the Isthmus of Panama. A skilled navigator, he was impressed with Canada's vast water resources, and particularly with the possibilities they presented for further exploration:

> It must be said also that the country of New France is a new world, and not a kingdom; perfectly beautiful, with very convenient locations, both on the banks of the great river (the ornament of the country) and on other rivers, lakes, ponds and brooks . . . a network of great rivers and lakes which are like seas lying across the countries, lend great facility to all the explorations of the interior, whence one could get access to the oceans on the west, the east, the north, and even on the south.[8]

By the time this account was written, Champlain had certainly followed the Ottawa River route to Lake Huron, and had navigated through the Trent River system and across Lake Ontario in canoes with a Huron war party. He had also heard accounts of the salt sea to the north, of the relatively easy portage from the Great Lakes to the Mississippi River system, and of the possibility of a journey through the Nelson and Mackenzie watersheds to the west coast. All of these routes would be followed by Europeans for purposes of exploration and trade

before the end of the eighteenth century. Champlain's account foreshadows by some 150 years the voyage of Alexander Mackenzie to the mouth of the river that bears his name.

Champlain's journals emphasize the abundance of waterfowl in eastern Canadian waters, and the excellence of the fishing in the early seventeenth century. Among the birds he noted on Canadian rivers were,

> . . . all sorts of ducks, teal, white and grey geese, bustards, little geese, woodcock, snipe, little and big larks, plover, herons, cranes, swans, divers of two or three kinds, coots, ospreys, curlievs, thrushes, white and grey seagulls.[9]

He further suggested, in part as an incentive to settlement, that for the fisherman,

> . . . there are rivers, brooks, lakes and ponds in as great number as one could desire, with an abundance of salmon; very beautiful trout, fine and large, of every kind; sturgeon of three sizes; shad; very good bass, some of which weigh twenty pounds . . . (etc.)[9]

The notion of the 'unlimited' character of Canada's water and wildlife resources probably has its origins in early explorers' accounts such as these.

Trade

Contact between European and Native cultures had probably been established to a certain extent by the time of Cartier's first voyage in 1534. Natives encountered in the Baie de

Chaleur had held fur pelts in the air as an inducement to Cartier and his men to come ashore. This has indicated to many scholars that these Natives had seen Europeans before and knew that they could acquire valuable iron knives and hatchets by bartering the furs which they wore. It is clear from this and other evidence that the fur trade first developed as a by-product of the coastal fishery, particularly after the shift from a "green" to a "dry" fishery -- implying the need to construct and maintain drying stages on shore -- produced greater contact with Native populations.

The fur trade emerged as a distinct economic activity in the second half of the sixteenth century. Harold Innis places this development in the context of a "revolution" in the conditions of supply and demand affecting beaver fur. In supply terms, as Natives became more and more dependent on European products, they went further and further into the interior in search of furs. In demand terms, there was a rapidly growing market for felt hats in Europe. Because it has the property of being minutely barbed, beaver fur was considered the best in the production of felt. Other types of fur found ready European markets as well, and huge profits were made by traders who exchanged tools they regarded as 'trinkets' for valuable furs.[10]

Easterbrook and Aitken suggest that the reason that the French were so pivotal in the early fur trade was the they could not make any headway against mainly English competition in the coastal fishery. Driven up the St.

Lawrence, the French encountered Natives who were interested in acquiring the iron and copper implements which could make their lives so much easier, and whose only marketable commodity was fur. These economic historians argue that the fur trade developed slowly in the period 1500-1550 because the French were mainly in contact with Natives of the Iroquoian cultural group, which got its sustenance mainly from agriculture and fishing. They suggest that the pace of the trade quickened once contact with the Algonquin and Montagnais peoples of the Saguenay region was made. Sometime after 1540, these hunting peoples probably drove the Iroquoians -- such as those whom Cartier had encountered at Hochelaga in 1535 -- south of the St. Lawrence, so as to establish control of the important St. Lawrence - Ottawa route to the interior. These Native groups, it should be emphasized, already controlled the Saguenay, which was among the most important arteries used in the early trade. Easterbrook and Aitken summarize the situation in the second half of the sixteenth century as follows:

> The principle [routes] to the interior [were] now controlled by hunting Indians, highly skilled in trapping beaver and familiar with the best hunting grounds. While the English continued to dominate the richer regions of the fisheries and the mainland to the south, French influence was pushed steadily along the St. Lawrence and Ottawa in pursuit of the beaver.[11]

This push along Canada's rivers and lakes towards the interior, and the generally westward extension of European influence as it followed the 'beaver frontier' was to be a constant theme in Canadian history for the next 250 years.

The role of water in this story was, of course, central. Fresh water represented, first and foremost, the only suitable medium for the transportation of goods in any quantity over long distances. As suggested earlier (Section 2), Algonkian peoples made excellent canoes; these were well adapted to their journeys into the interior in search of new sources of fur. Water was also the habitat of the principle article of commerce, the beaver. Its sedentary habits, and its construction of readily identifiable dams and lodges in the water meant that it was easily located by the experienced Native hunters. The explorer David Thompson has evoked the further advantages accruing to these hunters on the basis of their acquisition of European technology:

> Formerly, the Beavers were very numerous, the many Lakes and Rivers gave them ample space, and the poor Indian had then only a pointed stick shaped and hardened in the fire, a stone Hatchet, Spear and Arrowheads of the same; thus armed he was weak against the sagacious Beaver who on the banks of a Lake made itself a house of a foot thick or more; . . . . But when the arrival of the White People had changed all their weapons from stone to iron and steel and added the fatal gun, every animal fell before the Indian . . . .[12]

Against the new fashion for felt hats in Europe, the huge profits which the French traders could count on, and the technological revolution represented by the Natives' acquisition of iron and steel weapons -- ultimately including guns -- as well as other manufactured goods, the peaceful, industrious beaver didn't stand a chance. The second half of the six-

teenth century saw the beginning of the quasi-systematic slaughter of this species, starting in the St. Lawrence and its tributary basins, and moving relentlessly westward via the St. Lawrence, Ottawa and Saguenay routes over the next several hundred years -- at least until beaver hats gave way to silk in the European marketplace in the nineteenth century.

Initially, it was the Natives who did most of the travelling. In the early years, they brought furs from previously untapped sources to trading posts, generally located at the mouths of rivers. Tadoussac, at the junction of the Saguenay and the St. Lawrence had sufficient anchorage for ocean-going vessels, and was the most important French trading post of this period. Natives would travel substantial distances, often portaging over heights of land to get there. Champlain describes the Natives of the St. John River basin travelling by water and over land to trade at Tadoussac in the first decade of the seventeenth century.[13]

By this time, certain tribes were acting not only as producers in the French fur trade, but as middlemen. Certain Algonkian tribes living in the Saguenay basin -- notably the Montagnais -- had begun to acquire French trade goods on credit and transport them into the interior for the purpose of trading with tribes living in other drainage basins. These Natives were initially unwilling to allow Frenchmen to accompany them on their trading missions because they felt that their lucrative position as middlemen might be jeapordized. Champlain's curiosity about the various routes to the interior --

a curiosity steeped in the long-standing search for a "Northwest Passage" -- was not to be left entirely unsatisfied. But he was often forced to rely on Native accounts such as the following elicited from the middlemen on the Saguenay route:

> The savages reported to me that after passing the first fall they pass eight others; they then go on a day's journey without meeting any, and again pass ten others and enter a lake [Lac St. Jean] which takes three days to cross; and they can easily make ten leagues a day upstream. At the end of the lake there are tribes who lead a wandering life, and three rivers which empty into this lake, one coming from the north very near the sea, where they consider it to be much colder than in their country . . . . This is the region to which our savages go with the merchandise we give them to exchange for the furs which the others have, such as beaver, marten, lynx and otter, which are found there in large numbers and which they then bring to our ships [at Tadoussac]. These northern tribes tell our savages that they see the salt sea, and if that be true, as I think it certainly is, it can be nothing but a gulf entering the continent through the northern regions.[14]

Through Native accounts of their trade routes and their contact with other tribes, Champlain had correctly guessed at the character and location of Hudson Bay, independently of Henry Hudson's voyage in 1610.

Notes to Section 3

1. David B. Quinn, North America from Earliest Discovery to First Settlement: The Norse Voyages to 1612 (New York: Harper & Row, 1977).

2. Leif Eirikson's Saga, quoted in Ibid., p. 27.

3. Quinn, pp. 119-121.

4. H.P. Biggar (ed.), The Voyages of Jacques Cartier (Ottawa: Public Archives of Canada, 1924) pp. 90-91. There is some question as to whether Cartier was actually the author of his Voyages. From some of the syntax, it would appear as if another officer may have been responsible for keeping the ship's log, on which the accounts are based. Nonetheless, citations from Cartier's Voyages are here attributed to Cartier, primarily for purposes of smoother exposition.

5. Ibid., p. 106.

6. Ibid., pp. 113-4.

7. Ibid., p. 103, n. 68; p. 107, n. 88; p. 128, n. 76.

8. E.G. Bourne (ed.), The Voyages and Explorations of Samuel de Champlain (1604-1616) Narrated by Himself (Toronto: The Courier Press Ltd., 1911) p. 3.

9. Ibid., pp. 6-7.

10. H.A. Innis, The Fur Trade in Canada: An Introduction to Canadian Economic History (Toronto: University of Toronto Press, 1930, 1956) pp. 10-15.

11. W.T. Easterbrook & W.T. Aitken, Canadian Economic History (Toronto: The Macmillan Co., 1965) p. 40.

12. Cited in Innis, pp. 5-6.

13. Bourne, p. 79.

14. H.P. Biggar (ed.) The Works of Samuel de Champlain (Toronto: the Champlain Society, 19[illegible]2), pp. 4[illegible]-2.

Section 4:
Settlement & Expansion, 1608-1800

This section is meant to cover the period from the founding of Québec to the turn of the nineteenth century. These years saw the implantation of agriculturally-based settlements in the St. Lawrence Valley, Acadia and later, Upper Canada. They also saw the westward extension of the fur-trade frontier, primarily via the Ottawa River-Georgian Bay route, but after 1670 from Hudson Bay as well. Both settlement and the expansion of trade were dependent on the availability of water: most obviously to drink, in food preparation and for local and long-distance transportation, but also in a number of other important ways. Water was used as a source of power for grinding grain and sawing boards in new France and Acadia; the emergence of this type of water-based technology in the early settlement period will receive a good deal of attention here.

Beginnings

The beginning of the settlement phase of Canadian history is generally dated from the establishment of Québec by Champlain in 1608.[1] One could perhaps more appropriately begin an account of settlement in the year 1604, when a French expedition led by Pierre du Gua, Sieur des Monts attempted to pass the winter on an island in the mouth of the Ste. Croix River on the Bay of Fundy. The disastrous results of that attempt are

well known: 35 of the would-be settlers did not survive the winter. As a result, the settlement had to be relocated, and in 1605 des Monts founded Port Royal in Nova Scotia's well-sheltered Annapolis Basin.

Port Royal was an early attempt to establish an agriculturally based settlement in North America. An historian of water-power in the United States, L.C. Hunter, suggests that for such a settlement to become viable, one of the earliest and most fundamental needs was for an efficient means of grinding grain into flour.[2] Port Royal was in this respect no different from the American frontier communities studied by Hunter. By March 1607, des Monts' colonists had begun the construction of a water-powered gristmill on the Lequille River, which was to be the first of its kind in North America.[3]

The settlement at Port Royal, however, lay fallow between 1607 and 1610 because the Sieur des Monts had lost his Royal Charter. It is for this reason that Québec is generally considered the first permanent French settlement in the New World.[4]

Champlain, in his account of the first autumn spent at Québec, describes some of the preparatory work which had to be done in order to establish a settlement. The first tasks were the clearing of land for agriculture and to obtain wood for building. On July 3 1608, Champlain chose for his settlement

> . . . the point of Québec, so called by

> the savages, which is covered with nut-trees and vines. I at once employed a part of our work-men in cutting them down to put our buildings there, another part in sawing planks, another in digging the cellar and making moats, and another in going to Tadoussac with the pinnace to fetch our effects . . . .
>
> While the carpenters, sawyers and other workmen were busy at our quarters, I set all the rest to clear the land about our buildings to make gardens in which to sow grains and seeds, in order to see how they would all succeed, since the soil seemed to be very good.[5]

Such were the beginnings of the colony which grew up on the banks of the St. Lawrence and its tributaries between 1608 and 1763.

Settlement

Agricultural economies such as those which developed in New France and Acadia needed water, as already suggested, for a wide variety of reasons. Water-powered mills were used to grind grain for food and to saw boards for shelter. Water remained the most important means of transportation; the colonists not only adopted the canoe, but began to construct European-styled boats, including small bateaux, medium-sized sailing ships for navigation on the Great Lakes, and large sea-going vessels for use in the king's navy. Access to water was also important with respect to settlement patterns. Habitants considered it important to have river frontage on their concessions: hence the characteristic elongated shape and riparian orientation of Québec farms. And water-based natural resources were important, since most settlers

fished and hunted to supplement their diet.

Mills

Two of the primary needs of any pioneer economy were gristmills and sawmills. Hunter argues that in the United States,

> Gristmills and sawmills were among the first community facilities obtained in frontier areas, in most regions taking precedence over schools, churches, and stores and coming well in advance of wagon roads.[6]

In Canada, things were much the same. Without the benefit of a gristmill, grinding grain was a long and strenuous process, usually involving some form of mortar and pestle. Similarly, the boards required for building could only be obtained at the expense of a substantial amount of labour prior to the arrival of the sawmill.[7]

Clark (1968) suggests that "two gristmills (one water and one wind) and a second water mill, doubling for grinding grain and sawing wood" were in operation in the Annapolis Valley by the late 1680s.[8] Marcel Trudel counts nine wind-powered gristmills in the St. Lawrence Valley in 1663, and four water-powered mills.[9] Clark suggests that the wind-powered mills were in a sense superior to water mills because the latter type were occasionally put out of production by droughts. This may explain the predominance of windmills in early seventeenth century New France. Alternatively, the geography of the Quebec City region, where most of the mills were located, may have rendered the operation of wind-powered

mills less costly.

On this subject, Clark cites the accounts of two French travellers who visited Port Royal shortly before it was ceded to the English, and gives further evidence of the importance of water-powered mills in Acadia:

> Dièreville also reported three mills, describing one as for grinding corn and two as for the sawing of timber, and locates them on the stream south of the settlement. Villebon mentions boards from Port Royal, and says they had two sawmills and four water mills for grinding grain. Certainly there were mills up the river; Pierre Thibodeau, who established the first settlements at Shepody, had been a miller at Pré Ronde. Moreover, these mills were turning out a good deal of flour to supply the garrison and visiting ships, and even for trade.[8]

It is useful to point out that any time a barrel of flour is mentioned in historical documents of this period (and well into the nineteenth century), one is forced to think in terms of gristmills for the production of the flour itself, and of sawmills for the production of barrel staves -- not to mention the sawn lumber used in the construction of the ships used to transport the flour. Bread, of course, was much more important in the European diets of the seventeenth and eighteenth centuries than it is today. And water entered the production of a loaf of bread at almost every stage.

With respect to the importance of sawmills in New France, Fauteux suggests that the Jesuits had one in operation at Québec in 1646, if not before. Sawn lumber became more important as the settlement grew. It was needed for floors,

roofs and household furniture in particular. In 1646, the Jesuits hired one E. Bougoust "comme charpentier et pour aider au moulin." In 1650, the governor conceded to the Ursuline sisters a plot of land known as "rivière du moulin à la planche," and later christened "rivière à la scie," strongly indicating the presence of a water-powered sawmill on the site.[10]

Jean Lunn has summarized the principle uses of wood in colonial Canada. In addition to being the most important construction material, "Wood had also to be supplied for boats, barrels, furniture, sleighs, carriages and so on." Wood was cut in the winter by the habitants; it was then either used by the habitant himself or sold to a miller, who might have a contract in town to supply lumber for a particular purpose. Wood was so widely used in New France that by 1713 certain seigneuries had been stripped of trees, and additional grants had to be made for timber supply. The number of sawmills in the colony increased from 10 in 1716 to 70 in 1739, a period during which the population approximately doubled.[11]

Peter Kalm, a Swedish naturalist who toured New France in the last decade of the French régime, gives a description of the residence of the Governor of Montreal in 1750. The residence was located on an island in the St. Lawrence, where there was also a water-powered gristmill in operation. Kalm's colourful account is worth quoting at some length:

> This morning I accompanied the governor,

> Baron de Longeuil, and his family to a little island called Madeleine, which is his own property. It lies in the St. Lawrence River directly opposite the town on the eastern side. The governor had there a very neat house, though it was not very large, a fine, extensive garden, and a yard. The river passes between the town and this island, and is very rapid. Near the town it is deep enough for large boats, but towards the island it grows more shallow, so that they are obliged to push the boats forward with poles. There was a mill on the island, turned by the mere force of the stream, without an additional mill-dam. In the mill I noticed that the stones did not consist of one single piece but were made of several pieces. The upper millstone was quite large, made of eight parts which were joined very close together and bound with a thick iron band. The lower stone was the same. The upper one had been imported from France but the other was native . . . . The wheels and axle were made of white oak, but the cogs of the wheel and other parts of the machinery were made of sugar maple or wild cherry. Still, the former was said to be the most in use, because it was considered hard wood, especially if it had grown in dry places.[12]

Kalm also described the seigneurial mill operated by the Sulpician Order in Montreal at mid-eighteenth century. This must have been a comparitively large mill, since the seigneurie of Montreal comprised the entire island, and because the droit de banalité obliged the censitaires to have their grain ground at the seigneurial mill in exchange for a certain proportion of the flour thus obtained:

> The priests of Montreal have a mill where they take the fourth part of all that is ground. However, the miller receives a third part (of the seminary's portion) for his share. . . . The mill is built of stone with three waterwheels and three pair of stones.[3]

The other side of the droit de banalité was that the seigneur was legally obliged to build a mill for the use of his censitaires. In the seventeenth century, many seigneurs failed to comply with this obligation, with the result that -- as suggested earlier -- there were only 13 gristmills in the colony by 1663, when it was incorporated as a Royal Province of France. Furthermore, many of these mills were operated by enterprising habitants who received seigneurial authority to build and operate a mill, rather than by the seigneur himself.[14]

Cole Harris has suggested that the reason the seigneurs were slow in setting up gristmills was that the initial outlay for a mill was high, and that there was no guarantee of a return on the investment unless there were at least 25 families living on the land. In 1667, the gristmill banalité was fixed at one fourteenth of the grain ground: a rate much lower than that observed by Kalm at Montreal eighty years later. Legislation was passed in 1686 obliging the seigneur to build a mill within a year of taking possession of his land, or forfeit the droit de banalité. Harris argues that from the seigneur's standpoint,

> The construction of this mill was his principle seigneurial expense. The largest of them, like the stone mill on Terrebonne, which was one hundred and twenty feet long and forty wide, three stories high and fitted with granaries on the top floor, and four pairs of water-powered millstones below, or a similar mill belonging to the Séminaire de Québec at Petit Pré in Beaupré, probably cost the seigneurs at least 10,000 livres.[15]

Even the smaller mills, which might from the outside resemble small farmhouses, could cost as much as 2,000 livres to build.[15]

By 1688, there were 44 gristmills in New France -- 31 more than the number counted by Trudel in 1663. Harris suggests that about half of these were profitable to the seigneur. With population expansion in the first half of the eighteenth century, the number of mills in the colony grew apace, not least because as the seigneuries filled up, the operation of a mill became increasingly lucrative. After 1700, complaints about seigneurs' failure to build mills died down; by the end of the French régime, "Very few settled seigneuries were without a mill, and some had four or five."[16]

Transport

Water as a means of transportation remained vital in the settlement phase of Canadian history. Ocean-going ships would generally sail up the St. Lawrence as far as Québec, where a shipbuilding industry was begun in the 1660s under Talon's intendancy. Various kinds of _bateaux_ -- a term which covers many types of vessels, from simple rowboats to sloops and barques -- were constructed for the navigation of the trickier waters between Québec and Montreal. Canoes, of course, were the mainstay of the fur trade. Although the French did make efforts to navigate the upper St. Lawrence in _bateaux_ in this period, fur transport was cheaper by canoe on the Ottawa than by boat on the Lakes. Habitants used

canoes to take their produce to market and to visit neighbours; they also used the rivers for winter-time transportation, travelling in sleighs or on snowshoes.[17] More attention will be paid to the question of water-transportation when discussion turns to westward expansion later in this section.

Land Use

Settlement patterns in New France generally followed the St. Lawrence, except where it was broken by tributaries. Seigneuries and rotures (individual concessions) were granted along the St. Lawrence and its navigable tributaries in the form of "long, narrow trapezoids," so as to allow maximum river frontage for all concerned. Harris -- who is the foremost historical geographer of New France -- explains the general pattern of agricultural development:

> With approximately forty inches of rain a year everywhere in the colony the tributaries were not needed for irrigation, but many provided power for saw or gristmills, water for stock, and water for household use. When a tributary was navigable, and access to it from the land was easier than to the St. Lawrence, settlement often followed its course, and seigneuries were conceded along the most important tributaries as they were along the St. Lawrence.[16]

Fishing

For the habitant, particularly if -- as most did -- his land bordered on a water-course, fish represented an important dietary item and a possible source of additional

revenue. Eels were particularly abundant in the St. Lawrence in September and October, and the river also yielded such species as salmon, sturgeon, carp and catfish.[18]

Censitaires were generally allowed to fish for subsistence in the waters bordering their rotures without fear of seigneurial exactions, a right which was confirmed by the Governor Lauson in 1652. But the seigneur extracted a profit from any commercial fishing the habitant might venture. In the suburbs of Québec, fishermen were required to give one twenty-fifth of the eels they caught to the Compagnie des Cents-Associés, seigneurs of the region at the time. Rates varied from one seigneury to another, usually between one thirtieth and one eleventh of the catch, and the species most often taken commercially were eels and salmon. Certain religious communities had special privileges with respect to the St. Lawrence fishery. In the mid-seventeenth century, for example, Québec's Hôtel-Dieu enjoyed a monopoly on commercial fishing in the mouth of the St. Charles River.[19]

Industry

Though it is ignored in most accounts, there was a good deal of craft-based industrial development in New France, much of it involving the exploitation of water resources. Fauteux suggests that there were two main periods of industrial growth during the French régime: Talon's intendancy (1665-68; 1670-72) and that of Hocquart (1735-1745). Talon succeeded in establishing a brewery, a tannery, and manufactories engaged

in the production of cloth, hats and shoes. In addition,

> . . . il fait exploiter des pêcheries et les forêts. Il construit des vaisseaux, envoie à la découverte des mines, entreprend la manufacture du gourdon et de la potasse.[20]

After a period of decline in all these sectors, shipbuilding was revived under Hocquart, the exploitation of forests increased, the number of sawmills multiplied, and the fisheries prospered.

It remains to be pointed out that such establishments as tanneries, breweries, forges -- such as the one built on the St. Maurice River in the 1730s -- and textile mills made abundant use of water, primarily as a source of energy to drive machinery, but also as a process input and as a means of waste disposal.

Expansion

Westward expansion and exploration in this period occurred primarily in the context of the development of the fur trade. Between 1608 and 1760, the French expanded their trading empire over a vast portion of the North American interior, spanning the St. Lawrence, Nelson, Mississippi and Mackenzie drainage basins. Challenges to this empire were not infrequent. In 1653, the Iroquois succeeded in cutting off the vital Ottawa route entirely, so that no furs were sold at Montreal that year. In 1670, the English established the Hudsons Bay Company as a means of competing with the French for the trade of (what is now) western Canada. And in 1759, the French Crown lost

the ultimate struggle to maintain its interests in Canada with the defeat of Montcalm at Québec. This left the St. Lawrence-Great Lakes route, and the Ottawa-Georgian Bay route open to the English, who already controlled the northerly approach via Hudson Bay. After the Conquest, the Northwest Company was quick to capitalize on the upstream flow of merchandise and the downstream flow of furs which had fuelled the growth of Montreal -- the crucial trans-shipment point -- during the French régime.

Eric Morse has pointed out the rather extraordinary extent to which Canadian waters are navigable by canoe:

> The really amazing feature of Canadian geography . . . is the amount of fresh water in Canada: half of the world's fresh water surface. The rivers are not only closely connected but, for a portable craft adapted to the interrupted navigation, are entirely navigable.[21]

As suggested earlier, it was the Natives who did most of the travelling in the early fur trade. After the establishment of Québec, the Ottawa River - Georgian Bay route emerged as the key to the fur trade of the western interior. Champlain himself explored this route in 1615, probably the first European to do so. With the aid of Huron Indians, the French began transporting trade goods -- which were as yet new, unfamiliar, and certainly extremely valuable to the hunting tribes of the west -- up the river, and canoe-loads of furs downstream. Initially, the Hurons benefitted greatly from their position as middlemen, but in the end it cost them dearly. By the mid-seventeenth century this tribe had been virtually destr[illegible]

by Iroquois groups who were probably armed with English guns, and who sought to control the Ottawa on behalf of their allies based in New York. After 1660, the French established "new connections" among the Native tribes, strengthened the garrison at Montreal, and as a result, were able "to defeat the Iroquois and gain firm control over the route."[22]

French fur-trading developed along the Ottawa River route for a number of reasons. Most importantly, it was shorter and better adapted to canoe-travel than the St. Lawrence - Great Lakes route; it was also less susceptible to interference from the Iroquois and the English. In the seventeenth century, small posts were erected along this route for purposes of local trading. But its chief importance throughout the French régime and for a number of decades afterwards was as a means of access to the Upper Great Lakes, and from there to the river systems of the prairies.[23]

Beyond the Great Lakes there were a number of possible routes into the west. The principle route used by the French led from what is today Thunder Bay by the Kaministiquia River to Rainy Lake, and from there via the Rainy River to Lake of the Woods. After 1670, of course, the English began establishing fur-trading posts on the rivers flowing into Hudson Bay. Throughout the eighteenth century, there was competition between the trade which flowed out through the upper Lakes, the Ottawa and the St. Lawrence, and that which flowed through Hudson Bay. The late-eighteenth century rivalry between the Hudson

Bay Company and the Northwest Company based in Montreal was the result of this competition between two trade routes. There was also a difference in approach to the fur trade. While the Montrealers established long lines of communication with the interior, the Hudson Bay Company remained at their posts, offered better prices for furs, and had the Native trappers come to them. It was because of the high transportation costs involved in a continent-wide fur trade based on canoes that the Montreal-based fur-trade declined in the early nineteenth century.

The ease with which access to the west was acquired by Europeans in the seventeenth and eighteenth centuries should not be exaggerated. Day to day life on long-distance canoe trips was extremely demanding, as the French coureurs de bois and later the voyageurs in the employ of the Northwest Company found out. Still, there were only two watershed divides to impede canoe travel between Georgian Bay and the Mackenzie River system. This meant that French fur traders needed only reliable canoes and strong men to expand their interests well into the western interior of Canada.

Notes to Section 4

1. Easterbrook and Aitken treat this date as the beginning of the French attempt to control the fur trade of the St. Lawrence.

2. Bread, of course, is a basic need of any community. See L.C. Hunter, *A History of Industrial Power in the United States* vol. 1 "Waterpower in the Century of the Steam Engine" (Charlottesville: The University of Virginia Press, 1979) p. 3.

3. Andrew Clark, *Acadia: The Geography of Early Nova Scotia to 1760* (Madison: University of Wisconsin Press, 1968) p. 79; *Canada Water Year Book*, 1975, p. 7.

4. The Royal Charter granted the holder exclusive rights to the fur trade in a given region in exchange for the obligation to promote settlement.

5. Biggar (ed.), *Works of Champlain*, p. 49. A pinnace is "a light sailing ship used largely as a tender," -- or a supply ship (Webster's).

6. Hunter, *Industrial Power*, p. 3.

7. In the absence of a sawmill, many early pioneer homes went without floors.

8. Clark, *Acadia*, p. 178.

9. Marcel Trudel, *Les débuts du régime seigneuriale* (1974), p. 194. Sawmills do not appear to have been included here.

10. J.N. Fauteux, *Essai sur l'industrie au Canada sous le régime française* (Québec, 1927) p. 173.

11. A.J.E. Lunn, "Economic Development in New France, 1713-1760," Ph. D. Thesis, McGill University (Montreal, 1942) p. 219.

12. Peter Kalm, *Travels into North America* (London, 1772) vol. 2, p. 407.

13. *Ibid*., p. 532.

14. Trudel, *Régime seigneuriale*, pp. 191-3.

15. R.C. Harris, *The Seigneurial System in Early Canada: A Geographical Interpretation* (Madison, 1966) p. 72.

16. *Ibid.*, p. 75.

17. *Ibid.*, p. 12.

18. *Ibid.*, pp. 163-4.

19. Trudel, *Régime seigneuriale*, p. 195.

20. Fauteux, *Essai sur l'industrie*, p. ix.

21. Eric Morse, *Fur Trade Routes of Canada / Then and Now* (Ottawa: Minister of Supply and Services, 1979) p. 27.

22. Innis, *The Fur Trade in Canada*, p. 43.

23. Glazebrook, *A History of Transportation*, p. 13.

Section 5: The Nineteenth Century

The nineteenth century saw a number of general developments in Canadian society which had important effects on the use of water. This was the period in which the continental character of the Canadian territory was established, and in which political control over the northern half of North America was consolidated through the formation of the Canadian state. In demographic terms, it was a century of unprecedented growth, both through natural increase and through immigration, and one which saw the concentration of population in cities of expanding size and economic complexity.

Related to urbanization was Canada's industrial revolution. Some time after 1850, this country emerged in a definitive way from an age of "wood, wind and sail" to an age of "steel and steam". It is perhaps this context of industrial transition which best accounts for the expanded scale and variety of water uses in the nineteenth century. Among other important developments related to water, this period saw the emergence of steam power in industry and transportation, and the execution of the first large-scale engineering projects for various purposes -- including improved navigation and urban water supply. It also saw important developments in Canadian resource extraction industries, particularly logging, and in manufacturing -- particularly in the large cities of the east. Water remained

vitally important to farmers. With the decline of wheat production on the seigneurial lands, Upper Canada emerged as Canada's breadbasket -- to be superceded at the turn of the twentieth century by the prairies. Finally, the attractions of Canada's system of lakes and rivers did not escape the naturalists of the Victorian Era, who made ample use of them for purposes of recreation.

The most appropriate way to sort out these developments is to take a "problematic" approach. In this section, five separate problems associated with the increasing scale and complexity of water use in the nineteenth century will be examined. Individual attention will be paid to the need for reliable urban water supplies, to the importance of water in transportation, to the industrial use of water, to the role of water in the expansion of Canadian agriculture and to the new importance of water-based recreation. All of these problems are best understood in relation to the three dominant societal trends of the period: demographic growth, industrialization and urbanization.[1]

Water Supply

Canadian cities underwent unprecedented growth in the nineteenth century. As in any society, the concentration of large numbers of people in relatively small areas raised questions of water suppy. In Canadian towns prior to the mid-nineteenth century, water for domestic use had been secured from private and public wells, and from carters.

Wells and water vendors were common features of pre-industrial towns, not just in Canada, but in Europe as well.

In rural areas, water supply was not a problem where settlement was located near a river or stream -- as it usually was. Later arrivals, who were often unable to acquire land close to shore, made use of Canada's ground-water supply. Nineteenth century settlers in Ontario dug wells, normally to a depth of six to eight metres. They used a number of methods for drawing the water, including pumps made from hollowed out logs and activated by a rod and a leather plunger, and the familiar rope and windlass arrangement with a bucket at one end of the rope.[2]

F.W. Robins, in his The Story of Water Supply, alludes to an ancient technique for drawing water which was in use in colonial New Brunswick and Nova Scotia. This method employed a shaduf, which consisted of

> . . . an upright post on which was balanced a "cross-tree" arrangement or beam, having at one end a counterpoise weight and at the other a water vessel - in ancient times an earthenware pot.[3]

Robins attributes the presence of the shaduf in New Brunswick and Nova Scotia to the early influence of the French colonists. If this is the case, one might assume that similar arrangements had been in use in New France.

But it is really to the growing cities of the nineteenth century that the story of expanding water-supply requirements belongs. To take Montreal as an example, census figures show that this city doubled in size between 1825 and 1844, and did

so again between 1844 and 1861. Between 1825 and 1871, Montreal grew up from a town of 22,000 to a city of over 100,000. Its population would continue to expand at a similar rate will into the twentieth century. Eastern Canadian cities more generally went through an important growth phase in the period between 1840 and 1900. Associated with this growth was the recognition of the need for reliable urban water supplies.

The first public water works in Canada were built in St. John, New Brunswick in 1837. St. John was a port town specializing in the timber of the St. John River basin; its merchants profited from lively harbour-front activity. But there were sanitation problems associated with this activity which the early implementation of a public water-works system may have helped alleviate. An historian of New Brunswick, W.S. MacNutt, suggests in discussing the early nineteenth century that the port of St. John conveyed a pleasant impression from a distance,

> . . . but towards the wharves where scores of vessels lined up for traffic on the ocean and the river, filth became excessive and the summer sun raised unpleasant stenches.[4]

Surely a municipal water supply and sewage disposal system went a long way towards relieving this problem.

The transmission of disease through impure water was a recurrent problem in nineteenth-century Canada. Cholera ravaged British North America in 1832 and 1834, and there were serious typhoid epidemics in the 1840s and 1850s. The need for a safe source of drinking water was one of the main

reasons for the development of municipal water supply systems in Canada. The question of organic waste disposal was also increasingly pressing as cities grew more and more crowded. In pre-industrial times, the only "conveniences" of this nature were night buckets and privy-pits. In cities, nearby streams often served as open sewers in which many types of waste collected. Such was the case with Montreal's St. Pierre River in the eighteenth and early nineteenth centuries.[5] The notion that "the most satisfactory and economical method . . . for disposing of the organic wastes of a community is by the water-carriage system"[6] was only just emerging in mid-nineteenth century Canada.

Following the establishment of public water-works at St. John, major cities in the rest of eastern Canada followed suit. Public water-works were instituted in Toronto in 1841, Halifax in 1848 and Montreal in 1857.[7] In 1860, Canada had six municipal water supply systems, and one more had been added by the early 1870s. Between 1870 and the turn of the century, the development of urban water systems took off. In 1880, there were 30 such networks in Canada; by 1890, that number had increased to 105, and again to 235 by 1900.[8]

The increased need for municipal water supplies was related to industrialization as well as to urbanization. A student of the subject pointed out in 1911 that

> Such establishments as sugar-refineries, starch factories, bleaching and dyeing houses, breweries, chemical works, and various other factories require an abundant water supply, and in some cases a high degree of purity.[9]

Just these types of industries were being established in Canadian cities in the second half of the nineteenth century. Other industrial needs included water for steam boilers, and for hydraulic elevators. The most important public use of the emerging municipal water supplies was in extinguishing fires. Canadian cities also used water for cleaning streets, in public buildings and in fountains.

Transportation

The nineteenth century saw at least two -- possibly three -- developments in the history of Canadian transportation which can be classified as "revolutions". The first was the construction of a series of canals for military and commercial purposes in eastern Canada. The second, concurrent with the first, was the application of steam power to river, lake and ultimately ocean navigation. The third -- which will receive the least attention here although it was in the long run the most important -- was the construction of railroads.

All three of these developments required water. The use of steam engines involved the mechanical application of the expansive property of boiling water. In this light, even the railroad boom, which began in the 1850s and culminated with the completion of the CPR in 1885, can be seen as the development of a water-based technology. Our concern here, however, is primarily with canal-building, with steam navigation, with the context in which these phenomena appeared,

and with their economic and social consequences.

Water transport had always been the basis of Canadian commerce. On the strength of its location at the head of navigation on the St. Lawrence and at the confluence of the two principle routes to the interior, Montreal had already emerged as the principle centre of Canadian commerce by the beginning of the nineteenth century. According to one theory of Canadian economic development, the initial "staple" product transported along this route -- furs -- gave way to Upper Canadian wheat and flour in the 1820s. While canoes had been well-suited to the transportation of furs, and continued to be the mainstay of the fur-trade of the western interior, the new commodities required larger conveyances -- such as "Durham Boats", bateaux, and later, steam-powered barges -- if they were to be profitably hauled eastward for export. In a word, this meant canals.

Such were the economics of the situation in the 1820s and 1830s, the first great phase of canal building in Canada. The geography of the situation has been summarized by Glazebrook in his History of Transportation:

> . . . the great waterways of Canada are tantalizingly near to being perfect for navigation, but there exist enough breaks in the chains of lakes and rivers to make it impossible to follow the natural waterways for more than limited distances. It was natural, therefore, that attempts should be made to facilitate, by means of canals, the passage of the St. Lawrence and Ottawa rivers, both on the central lines of French communication.[10]

Interestingly, there is a military context to be established as well. British North America had been the site of some border skirmishes during the era of the Napoleonic Wars, which are usually referred to as the War of 1812. Britain and the United States were anything but comfortable allies in the first decades of the nineteenth century. For Britain, the painful Revolutionary War was too recent a memory, and American egalitarian ideas and aggressive entrepreneurship were not to be trusted.

George K. Raudzens has emphasized the impact of defense considerations on the construction of Canadian canals between 1815 and 1825. He suggests that the original proposal for a canal to bypass the Lachine Rapids, made in 1814, was part of a military scheme to provide an alternative to the vulnerable St. Lawrence route between Monteal and Kingston, and was not originally intended as a spur to commercial navigation. This alternative route -- incorporating the Ste. Anne's Lock, the Ottawa River Canals at Carillon and Grenville, and the Rideau Waterway -- was completed in 1834 through the efforts of Colonel By and the Royal Engineers, at a cost far exceeding preliminary estimates. According to Raudzens, this was definitely not the waterway needed to open up Great Lakes commerce to Canadian ports.[11]

Plans to canalize the St. Lawrence route were supported by mercantile interests throughout British America. Lower Canadian merchants saw the possibility of diverting the agricultural produce not only of Upper Canada, but of the American

midwest through Montreal -- a possibility which rested on the construction of canals along the Upper St. Lawrence and between the Great Lakes.

If the context in which canal-building occurred is to be fully understood, some attention should be paid to the other "revolution" in transportation of the early nineteenth century: the advent of steam navigation.

The first steam-powered vessel to ply Canada's waters was the Accommodation, launched by John Molson's St. Lawrence Steamboat Company in 1809. The ship boasted a six horsepower engine and averaged 4½ miles per hour in its maiden voyage downstream from Montreal to Quebec. This type of performance did little to assure the public of the solid future of steam navigation.

As the application of steam-technology to navigation improved, more and more stern and side-wheeled vessels appeared in British North America. Molson's second vessel, the Swiftsure was launched in 1811. It had a 28 horsepower engine, which made it powerful enough to sail upstream from Quebec to Montreal -- something the Accommodation had been unable to do. Molson added three further steamers to his fleet between 1811 and 1818. By the 1820s and 1830s, steamboats were commonly used on the St. Lawrence, both for freight and passenger service.

Steam navigation was developing on the Great Lakes and on the Ottawa River as well. In 1816, the first steamer built for the lakes was launched at Kingston. Three years

later "The Ottawa" became the first steam-powered vessel to navigate on the river of the same name.

The commercial implications of this new form of transportation were quickly appreciated by British North American merchants. As early as 1816, the Québec Gazette would report that

> The Steam Boats have already ruined the prospects of the old River Craft, many of which long ago ought to have been condemned as unfit to receive the property of the merchant.[12]

But steam-boats could not negotiate the Lachine rapids, or the series of rapids between Lake St. Louis and Prescott -- much less the old portage route around Niagara Falls. If there was to be a "commercial empire of the St. Lawrence" based on the trans-shipment of Western agricultural products using comparitively reliable steam-power, canals had to be built. And they were.

There is inadequate time or space available to provide anything but a sketch of canal construction in British North America in the first half of the nineteenth century. The general framework -- that canals were necessary to the expansion of east-west trade in this period -- has already been established. The first attempts to improve communications on the St. Lawrence occurred in the late eighteenth century. Between 1779 and 1783, the Royal Engineers built a series of 4 canals to overcome the three sets of rapids between Lake St. Louis and Lake St. Francis. Two of these were replaced in 1804 by a single canal; in 1817 their width was doubled, and

their depth increased to 3½ feet, ". . . to admit Durham boats and bateaux capable of carrying a hundred barrels of flour."[13] These canals were replaced by the Beauharnois canal, built on the south shore between 1842 and 1845, which was 11¼ miles long, and had 9 locks with 9 feet of water on the sills. This canal was in use until the construction of the Soulanges canal in 1899.

Further up the river, navigation was interrupted by the Long Sault rapids. Here, construction of the Cornwall Canal was begun in 1837, but interrupted by the rebellion and by economic depression. When completed in 1843, the Cornwall Canal gave a nine foot channel around the rapids. Three further canals on the upper St. Lawrence were constructed in the late 1840s. Known as the Williamsburg Canals, these were less urgently needed, since steamers were in any case capable of overcoming the last set of rapids between Montreal and Kingston.

Some attention should be paid to the Lachine Canal, which was built to eliminate the need to haul goods and people across the southern tip of Montreal island from the port to Lachine by wagon. The idea for such a canal had been presented during the French régime, but it was not until 1824 that the first Lachine Canal was completed. Built by the Lower Canadian government at a cost of over £ 100,000, the original canal was nine miles long and had seven locks with five feet of water on the sills. The canal was improved between 1843 and 1848 to provide im-

proved navigation and facilities for the generation of hydraulic power. The new canal had five locks, each 200 by 45 feet. The three upper locks had nine feet of water, while the lower two had sixteen, "in order to allow the largest ocean going vessels to enter the first basin of the canal."[14] The canal was enlarged again in 1871, and gave way to a new Lachine Canal at the turn of the twentieth century.

Another crucial link in the Great Lakes to tidewater route was the Welland Canal. Like the other canals in what is now the St. Lawrence Seaway, this one has undergone many changes since it was first built in the early nineteenth century. William Hamilton Merritt's Welland Canal Company built the original canal between 1824 and 1829, largely in an attempt to offset the effects of the new Erie Canal on the St. Lawrence trade. This canal had a series of forty wooden locks and 9 feet of water on the sills. In 1840, the wooden locks were replaced by 27 stone locks, and the channel was deepened to 10¼ feet. Further changes and improvements were made in 1871 and 1887, when the depth of water reached 14 feet.

The consequences of canal-building and of the emergence of steam navigation were perhaps not as profound as the merchants and promoters of the age had hoped. By 1850, a new revolution in transportation was underway which would eventually link the country from coast to coast, enabling grain and other products to be transported faster, more efficiently and over

greater distances. Nevertheless, the canalization of Canadian rivers was an important stage in the development of the country's water resources for purposes of navigation.[15]

Industry

It has already been suggested that water was important to Canada's industrial development in the nineteenth century. For one thing, the sheer volume of water used in Canadian industry expanded as the country's economy emerged from the mercantile period into the age of industrial capitalism. For another, Canadian businessmen found a wide variety of new uses for what was clearly one of the country's most valuable resources.

Canadian industry will be divided into two large sectors -- resource extraction and manufacturing -- for purposes of this discussion. A good example of a nineteenth-century resource-extraction industry which made abundant use of water (aside from agriculture, which will be discussed separately) is logging. Attention will be focussed on the logging industry in early nineteenth-century New Brunswick, Quebec and Ontario. Later, discussion will turn to the development of manufacturing industry in Canadian towns in the period after 1850. Manufacturers used water as a source of energy, as a process input, and as a means of disposing of their waste products. Certainly, many modern-day pollution problems had their roots in the industrial transition of the later nineteenth century.

Logging was important in the St. John and Mirimachi basins of New Brunswick, in the Saguenay and St. Maurice basins in Québec, and -- perhaps above all -- along the Ottawa River in the early nineteenth century. The chief market for Canadian timber in this period was the shipyards of the Royal Navy in England. Cut off from her traditional Baltic sources, England fell back on the forest reserves of her colonies in North America during Napoleon's Continental Blockade (1806-1815). This was a boon to entrepreneurs in both Upper and Lower Canada, and in New Brunswick -- at this time still a distinct colony.

The importance of the timber trade in places like the St. John and Ottawa valleys and in the Saguenay cannot be over-estimated. Nor can its impact on the water-courses which were followed into the interior in the search for oak and pine stands, respectively to provide hulls and masts for English ships. According to one historical geographer who has studied the timber trade and its impact on New Brunswick, ". . . the timber trade transformed the colonial environment of eastern Canada."[16]

This student, Graeme Wynn, is also a good source on the importance of water to the early timber trade. He points out that logging was essentially a winter-time occupation, and that ". . . the lumberers relied upon the melting streams and rivers to float their timber to market in the spring."[17] He also refers to the various ways in which loggers would attempt to modify stream-flow to suit

their needs, most of which involved the use of dams:

> Sometimes streams were prepared for driving during the summer or early fall. As in Maine, dams were built to raise the spring water level along the smaller brooks and upper reaches of larger rivers. Many of these were substantial constructions, as much as seventeen feet in height. By fitting a dam with gates or sluices, water could be backed up and timber run down the system almost as through a set of locks. Alternatively, the drive might be accomplished by "blowing" or demolishing a series of simple dams as the wood moved downstream.[18]

Other modifications to New Brunswick's rivers included blowing out large rocks with dynamite, building sluices around falls and removing dead trees and other debris. Similar techniques were applied in Ontario and Québec in this period. In 1851, for example, the government of the United Canadas allocated $40,000 for the improvements to the St. Maurice River for logging purposes, "c'est à dire à la construction d'éstacades à billotes et de glissoires." By 1859, $218,100 had been spent on anchor piers, booms and slides at Trois Rivières, Les Grès, Shawinigan, Grand Mère and Latuque.[19]

In the Ottawa Valley, Philemon Wright drove his first timber raft downriver to Québec in 1807. Many picturesque accounts of the exploits of lumberjacks and raftsmen of this region exist. One recent description stresses the skill required by the raftsmen to guide rafts -- which were made up of up to 5,000 sticks of squared timber (pine and oak) worth some $170,000 -- down the Ottawa:

> Navigating these rafts was an art that called for special skill and strength. The raftsmen, headed usually by an Iroquois or a French Canadian, had to know how to take full advantage of wind and current; and when to hoist their primitive sails or to use their oars. It was a thrilling sight to watch one of these great rafts approaching and passing a stretch of rapids . . . . The timbers, captive yet flexible, would groan and grind together as they rose and fell on the surging water, speeding along at a breakneck pace, and barely escaping being torn asunder by the rocks in their path.[20]

After mid-century, the British market for colonial timber fell off, but logging remained an essential industry because of a growing market for sawn lumber in the United States.

The nineteenth century saw the expansion of British interests into the prairie and Pacific Coast regions of Canada. Much, if not all of this expansion was inspired by the wealth of the natural resources of the west. The first important western staple industry was, of course, the fur trade. There was still a market for beaver and other types of pelts in nineteenth-century Europe, and from the 1820s onward the Hudson's Bay Company dominated the trade of the western interior. Western rivers such as the Nelson, the Saskatchewan and the MacKenzie were now the locus of an industry which continued to rely on Native and French Canadian labour. The company's charter had assured its control over all lands drained by rivers flowing into Hudson's Bay. Rupert's Land, as this territory was called, came to consist of a string of fur-trading posts scattered across vast flatlands peopled chiefly by Natives. Little European settlement occurred

before Confederation, partly because of the H.B.C.'s narrow definition of its interests. Company policy, the isolation of the region, and its shortage of navigable waterways all mitigated against settlement, which would not occur to any important extent until after the coming of the railways. When settlers did arrive in the later nineteenth century, towns generally grew up on the sites of former fur-trade posts.

The fur resources of western Canada attracted traders from overseas in addition to those who travelled across the continent. The origins of the Pacific Coast trade can be found in the late eighteenth century. At approximately the same time as traders from the Canadian interior successfully extended their reach beyond the continental divide, explorers such as Captain James Cook began to establish trade links with coastal Indians. These Natives provided the seafaring traders -- including Americans, Englishmen, Spaniards and Russians -- with valuable furs -- such as that of the sea otter -- which could be sold at an enormous profit in China's ports. In the early nineteenth century, competition between British, American and Russian trading companies in the Maritime fur trade of the Pacific Coast was rife. Initially attracted by the profitability of the fur-trade, many Europeans remained in the area to exploit its rich salmon fishery -- thus reversing the pattern observed three hundred years earlier on the Atlantic Coast.

Other resources besides fur were to be found in the west, including the forestry and mineral reserves of British Columbia. For the most part, large-scale exploitation would not come until

the turn of the century. But the Fraser River gold rush of the 1850s was an important exception. Bruce Hutchison has described the character of the rush, which brought an influx of prospectors -- mostly American -- to the shores of the Fraser River:

> On every bar men were rocking, panning and sluicing. Every creek emptying into the Fraser was explored. Wherever prospectors found a fragment of float, a hunk of gold-bearing sand fallen from some bench above, they followed the lead into the hills.[21]

He also points to the potential for conflict between miners and Natives, who still used the Fraser River for fishing and as a fur-trade route.

Later in the century, another gold rush transformed the economy and geography of the Yukon River watershed. This was the great Klondike rush, which reached its peak in the summer of 1898. At this point Dawson City, which had grown up at the confluence of the Klondike River and Bonanza Creek near the point where George Carmack had staked his discovery claim in 1896, achieved a population of some 20,000 souls, most of them miners and prospectors. The value of placer gold mined in the Yukon increased from $300,000 in 1896, to $10,000,000 in 1898. Production continued to increase until 1900, as more effective means of extracting the alluvial gold deposits were found. The value of gold mined in the Yukon in that year reached $22,000,000.[22]

The mining of placer gold in the Yukon was complicated by the fact that the gravel beds in which the deposits were to be found, and the dirt and organic material (known as "muck")

which covered them were frozen year round. Various means of thawing the earth were adopted. The earliest miners simply built a series of wood-fires during the winter. In this fashion, they thawed out one or two feet of material at a time, gradually sinking a shaft to the alluvial deposits near bedrock. Once "paydirt" was reached, the material was piled in a dump near the stream, to be sluiced in the spring. This was often accomplished with the aid of a dam constructed upstream for the purpose of diverting water through a flume to a series of sluice boxes. Large quantities of water were diverted from streams wherever placer gold was mined. This was particularly true in the Yukon where exploitation of this mineral resource took place on such a large scale.

In the cities of Canada's east, in the meantime, manufacturing industries employing increasingly advanced production technology were emerging. The really "revolutionary" features of the industrial transition included the subdivision of the labour process into its composite tasks and the development of machine-tools to perform these tasks mechanically. L.C. Hunter has pointed to the erroneous character of the assumption that the application of steam-power was the crucial turning point in industrial development:

> The key innovation in the Industrial Revolution was the mechanization of hand operations and the use of mechanical power to drive the machinery. The kind of power adopted was a secondary consideration; the choice depending chiefly upon such basic factors as availability and cost.[23]

Hydraulic power was cheap and available in nineteenth century Canada, particularly after the canalization of the St. Lawrence, Ottawa, Rideau and other systems created a whole series of dams and locks which offered convenient direct-drive water-power sites. This form of industrial energy had been in use since the French régime, but it acquired a whole new importance in the early phases of the Industrial Revolution. Hunter suggests that

> Falling water was the chief source of stationary power at all levels, in most branches of industry, and throughout the greater part of the United States before the 1860s.[24]

There are very good reasons to believe that the same was true in Canada. Industrialization along the Lachine Canal, for example, depended to a large extent on the power generated by its locks. The first lock in the system was made available to industrial users in 1847. It was capable of generating enough power to run 80 pairs of mill-stones. By 1850, all twenty water-sites in the first basin of the Canal had been leased to the owners of flour mills, iron foundries, sawmills, shipyards, and paint and drug manufactories. By 1854 with the opening of the second lock, Lachine Canal power was also being used in the production of rubber footwear, cotton textiles, woolens, joinery (particularly doors and windows), furniture, barrels and axes.[25]

Industries which required water as a process input included breweries and distilleries, which were legion in nineteenth century Canada and which often developed in con-

junction with gristmills. Here was a means of putting the coarser grains and the surplus of the better grains to good use. Paper-making also involved quantities of water, and although the forest-based pulp and paper industry did not emerge until the turn of the century, there were primitive paper mills employing a variety of materials -- such as rags and straw -- as early as 1804.

The problem of industrial wastes polluting Canada's waters probably first emerged in the later nineteenth century. Although there is little literature on the question for this time period, it is safe to say that the quality of the water adjacent to industrial areas -- particularly in cities such as Montreal, Hamilton and Toronto -- had begun to decline by the 1860s.

The 1860s also saw the beginning of the "high period" of steam technology in Canadian industry. Water-power was a good way to run a factory; but there were only so many water-power sites available in the manufacturing centres. Steam engines, in the meantime, were becoming smaller, more affordable and cheaper to run. Much of the industrialization of the period 1860-1900 was accomplished on the basis of steam technology and coal trasported from Pennsylvania or Cape Breton. There were no appreciable coal deposits in what was already Canada's principle centre of population and industry: the Great Lakes - St. Lawrence basin. There were however, abundant water resources which had been widely applied in the early phase of industrialization and which would come to the fore again at

the turn of the century with the development of hydro-electric technology.

Agriculture

Above all, the story of Canadian agriculture in the nineteenth century is a story of westward expansion. "Western Canada", however, has meant different things at different points in history. From the coming of the Loyalist settlers in the 1780s through much of the nineteenth century it generally referred to Upper Canada, the Red River Colony (established 1812) notwithstanding. Afterwards, particularly once the great transcontinental railways were built, the settlement frontier moved further west, and the agricultural potential of the prairie region began to be realized. While agricultural settlements in Upper Canada and Manitoba were generally well-watered, farmers in Saskatchewan and Alberta often had to develop the irrigation potential of the rivers and streams which flowed across the prairie in order to make their land productive.

Upper Canadian agriculture was well underway almost as soon as the first Loyalist settlers arrived in the wake of the American Revolutionary War. As in Lower Canada, the fields cleared by these pioneers rarely needed irrigation. However, water was required for domestic use, for stock, for transportation, and as a source of energy to grind grain and saw boards.

The first gristmill in Upper Canada was built by the

colonial government on the Cataraqui River near Kingston in 1782-83. Many of the settlers brought steel coffee-mills which could be used to produce a coarse flour. But, according to Hunter,

> "Coffee-mill flour seldom made good bread," and most settlers managed to get fairly good milled flour "even if they tramped thirty miles for it."[26]

Early Upper Canadians carried grain over long distances, by bateau or canoe, on foot, or by sled in winter to have their grain ground at the Kingston mill.

The number of gristmills in Upper Canada multiplied as the good farming land was settled, and communities often grew up around mill-sites. In the canal-building era, many new mills took advantage of the hydraulic power generated as a by-product of improved navigation. By 1836, there were 600 gristmills in Upper Canada, most of them run directly by falling water.

The multiplication of flour-mills in early nineteenth-century Ontario reflects the emergence of an agricultural population whose economy was geared to the export of bread-stuffs. Between 1812 and 1860, the province's population grew from 75,000 to 1.4 million, primarily because of the richness of its soil. In 1867, 60% of the population was engaged in agriculture. For at least one economic historian, the strength of the Ontario wheat staple in the early nineteenth century was the basis for that province's subsequent viable and sustained industrial growth.[27] The importance of Ontario

wheat to Canadian commerce more generally is reflected in the fact that in 1850, wheat and flour represented some 78% of the total tonnage passing down the St. Lawrence canals.[28]

The emergence of agriculture in the prairie west was a phenomenon of the late nineteenth century. Prior to the 1850s, areas such as southern Alberta failed to attract settlers, and agriculture developed on a very small scale, chiefly in support of fur-trading posts.

The pessimistic Palliser report of the 1850s did little to encourage settlement on the western grassland. Palliser thought the area bordered by the South Saskatchewan River, the American frontier and the Rockies to be "mostly unsuitable for cropping" inasmuch as the land "generally lacked tree growth, and had limited water supplies and shortgrass."[29]

After Confederation, the situation in the west changed. New studies were commissioned by the government of Canada -- which acquired Rupert's Land from the Hudson's Bay Company in the 1870s -- to assess the agricultural potential of the prairies. The Macoun report contradicted Palliser -- who had seen the land during a period of drought -- and indicated that only 5% of the prairie was unsuitable for agriculture. This was grist for the mill of the government and the CPR, both of which had an interest in establishing a chain of settlements from coast to coast, not least as a means of checking American expansion into the northern prairies.

By the 1870s, American cattle interests had already begun establishing ranches in southern Alberta and Saskatchewan. These cattlemen had been pushed west and north by settlement in the American midwest, and were attracted by Canadian grasslands. Partially in order to consolidate their hold on the territory, the Canadian government passed the Dominion Lands Act in 1872, which authorized homesteading in the prairie region. Government and CPR policies were designed to encourage rapid settlement; in most regions, settlement followed the completion of the trunk rail lines into a particular area.

In the beginning, irrigation schemes were used by ranchers and farmers alike. The year 1878 saw the first recorded irrigation development in what is now Alberta. In that year, a farmer named John Glen diverted enough water from Fish Creek to irrigate his 20 acre plot near Calgary. The first recorded diversion in the Cypress Hills area occurred in 1888, when C.W. Sanders dug a ditch from Hay Creek to land southwest of Hay Lake. By 1895, seven irrigation schemes are known to have been operating in this region. These early diversion projects

> . . . were rudimentary in nature, consisting essentially of a structure in the channel to divert streamflow and a short ditch to carry the water to the land to be irrigated . . . . Few materials were involved; the main cost of the works was the labour invested by the operator . . .[30]

The need for irrigation in certain parts of Western Canada was not always acknowledged in the seats of power. During the 1880s, the Department of the Interior and the CPR

opposed official recognition of the need for irrigation in any part of the prairies because they felt it would discourage immigration. Widespread droughts in 1885 and 1889 made this sort of obstructionism futile and irresponsible. By 1890, settlers had realized that the moist conditions of the 1870s were not the norm, and had achieved a new awareness about the need for irrigation in the west. Through lobby groups such as the Irrigation League of Alberta, farmers began to pressure the government into changing its policies with respect to irrigation.

This pressure bore fruit with the passage of the Northwest Irrigation Act in 1894. This act established the concept of publicly administered irrigation districts -- although few such districts were viable before the turn of the century. The act also incorporated two important principles of Canadian water law which would act as precedents in subsequent legislation: ownership of surface waters was vested in the crown, and their use became subject to government license. Future development of western rivers and streams for purposes of irrigation would proceed on this more structured basis.[31]

Recreation

In modern Canada, recreation constitutes an important dimension of water-use and water management. In the nineteenth century, when urban-industrial society was new, water-based recreation was only just emerging. Previously,

fishing and hunting had been more closely associated with sustenance than with leisure, and boating had been a vital means of communication rather than a source of pleasure.

As the cities of the Victorian age became more and more crowded, and as industrial occupations became more and more monotonous, many people began to seek outdoor relaxation -- much of which involved a new sort of exploitation of Canada's water resource.

Between 1850 and 1900, a voluminous literature extolling the attractions of Canada's water-courses for the sportsman emerged. Some of these books and pamphlets were written with the intent of attracting immigration; others were pure travel literature, designed to allow a largely British readership to enjoy vicariously such natural wonders as Niagara Falls.

One such book was W.A. Adamson's Salmon Fishing in Canada, written in 1860 by an English parson resident in Canada. It was designed in part to encourage emigration to "the provinces of Great Britain lying in North America beyond the Atlantic wave." Above all however, Adamson was a sport fisherman. His enthusiasm for the attractions of Canada's inland waters knew few bounds; nor did his rhetorical flights, as the following passage will illustrate:

> Think of this, ye anglers, who have been all your lives pacing the margin of some over-fished river in England! - think of this, ye perservering labourers on the well-beaten waters of the Tweed, the Tay, the Eak, the Don, the Spey, the Ness, and the Beuly! - think

> of this, ye tired thrashers of the well-netted streams of Erne, Moy and Shannon! think that within less than a fortnight's steaming from your hall doors, there are as yet twenty-five virgin rivers in one small portion of Canada, [the north shore of the St. Lawrence below Quebec City] and that of the ten which have been tried, they have all, with one single exception, been found not only to abound in salmon, but to afford ample facilities for taking that noble fish with the rod and the fly.[32]

Adamson had one reservation about salmon fishing in Canada, and it is an interesting one because it illustrates the kind of conflict between uses which makes water-management necessary today. He suggests, with a good deal of regret, that salmon fishing west of Quebec had been virtually destroyed -- with the exception of a single stream, the Jacques Cartier -- not through over-fishing, but because of the profusion of mill-dams which made no provision for the passage of salmon upstream to their spawning grounds:

> No man in his senses will say that in a young country any obstruction should be thrown in the way of the erection of mills; but every man of reflection will grant that where they are built the rivers should not be so completely blocked up as to prevent a single salmon from ascending them.[33]

Adamson proposed the construction of salmon-leaps on rivers, particularly in Upper Canada. Supposing a mill-dam fifteen feet high, he suggested the erection of ". . . two boxes, each five feet high, one over the other, to enable the salmon, in three leaps, to reach the waters which nature prompts him to seek for the propagation of his species."[34] By his

calculations, such works could be constructed below the average Upper Canadian mill-dam for a sum not exceeding twenty dollars.

Though it is not clear whether Adamson's proposals were acted on, they serve to illustrate the competition between water users -- in this case between millers and their customers and recreational fishermen -- which was already apparent in the 1860s. With the multiplication of uses in the second half of the century, and the rise in the proportion of Canada's water which was being put to one use or another, the potential for conflict between users inevitably increased. In the twentieth century, government became more and more involved in sorting out the claims of the interested parties in these sorts of disputes.

Notes to Section 5

1. In the cases of agriculture and transportation, one might certainly add a fourth "fundamental trend": territorial expansion.

2. R. Kochi & D. Munchee, "Ontario's Quest for Clean Water," in Legacy 12:3 (summer, 1984) p. 23.

3. F.W. Robins, The Story of Water Supply (Oxford: Oxford University Press, 1946) p. 41.

4. W.S. MacNutt, New Brunswick, A History: 1784-1867 (Toronto: MacMillan 1963) p. 212.

5. It is today an enclosed sewer running below St. Antoine street.

6. F.E. Turneaure, H.L. Russel, Public Water Supplies: Requirements, Resources and the Construction of Works (New York: John Wiley & Sons, 1911) p. 13.

7. Canada Water Year Book (1975) p. 19.

8. D. Tate & D. Lacelle, "Municipal Water Use in Canada," Canadian Water Resources Journal 3:1 (spring, 1978) pp. 61-78. This trend, of course, continued into the twentieth century.

9. Turneaure & Russel, Op. Cit., p. 13.

10. Glazebrook, History of Transportation , p. 72.

11. George K. Raudzens, "The Military Impact on Canadian Canals, 1815-25," Canadian Historical Review 54:3 (September, 1973).

12. Quoted in Glazebrook, History of Transportation, p. 68.

13. G.W. Stephens, The St. Lawrence Waterway Project (Toronto: Warwick Bros. & Ruther, 1930) p. 264.

14. Ibid., p. 263.

15. Unwittingly, the canals introduced another problem which would not be fully understood until well into the twentieth century: biota transfer. The sea lamprey is a good example. Responsible for severe damage done to populations of lake trout, whitefish and chub in the Great Lakes in the 1940s and 1950s, this species was introduced to Lakes Ontario and Erie in the later nineteenth century via the Erie and Welland Canals.

16. Graeme Wynn, Timber Colony: An Historical Geography of Early Nineteenth-Century New Brunswick (Toronto: University of Toronto Press, 1981) p. xi.

17. Ibid., p. 54.

18. Ibid., p. 64.

19. Normand Lafleur, La drave en Mauricie des origins à nos jours: histoire et traditions (Trois Rivières: Editions du Bien Public, 1970) p. 31.

20. Ontario, Department of Lands and Forests, Renewing Nature's Wealth (1967) pp. 37-9.

21. Bruce Hutchison, The Fraser (New York: Rinehart, 1950) p. 55.

22. Adam Shortt, Canada and its Provinces vol. 22 (1914) p. 633.

23. L.C. Hunter, History of Industrial Power p. 151.

24. Ibid., p. 159.

25. Gerald Tulchinsky, The River Barons: Montreal Businessmen and the Growth of Industry & Transportation 1837-53 (Toronto: University of Toronto Press, 1977) pp. 221-8.

26. Hunter, History of Industrial Power. Internal citations are from E.C. Guillet, Early Life in Upper Canada (Toronto, 1963).

27. John McCallum, Unequal Beginnings: Agriculture and Economic Development in Quebec and Ontario until 1870 (Toronto: University of Toronto Press, 1980).

28. Excluding lumber products, which accounted for 10% of the tolls collected. Cf. McCallum, pp. 66 ff.

29. R.F. Smith, "History and Current Status of Irrigation in Alberta," Canadian Water Resources Journal 3:1 (winter 1978) p. 6.

30. John E. Glenn, "The Role of Government Legislation, Policy and Agency Activity in Irrigation Development: The Cypress Hills Area, 1888- c. 1968," Masters Thesis Geography, University of Calgary, 1968, p. 25.

31. Principle sources for this discussion are R.F. Smith, "Irrigation in Alberta," John E. Glenn, "The Cypress Hills Area," and H.L. Topham, "History of Irrigation in Western Canada," Prairie Farm Rehabilitation Administration, February, 1982.

32. W.A. Adamson, Salmon Fishing in Canada; by a Resident (London, 1860) p. 82.

33. Ibid., p. 21.

34. Ibid., p. 292.

Section 6:
The Twentieth Century

The period from 1900 to 1960 saw the continuation of certain trends established in the nineteenth century. Industrial growth, population expansion, the emergence of the west, urbanization: all of these had their roots in the demographic, economic and territorial expansion of the years 1850 to 1900.

The nineteenth century had also seen the emergence of the Canadian state. From the 1890s onward, the state played an increasingly important role in water development. The period after 1900 saw a multiplication of publicly funded and/or administered projects for hydro-development, navigation, water conservation, recreation, irrigation, drainage and flood control. All three levels of government and a growing number of special agencies became involved with Canada's water resource in the twentieth century.

Beyond this, the twentieth century brought entirely new orders of magnitude to almost every area of water use. Technological advances meant larger dams and more efficient river control; deeper and wider locks accommodated ships with increased carrying capacity, which meant vastly improved navigation; and, perhaps most importantly, a new means of using water to generate energy revolutionized industrial and domestic life. Just as electrically operated machinery improved efficiency and saved money for the industrialist,

electric lighting and appliances improved the home environment and reduced the domestic workload. At the macro-economic level, the development of the energy potential of Canada's rivers involved huge expenditures by both private enterprise and the public sector, and required engineering feats which far surpassed anything imagined in the nineteenth century.

Throughout Canada, the scale and variety of industrial uses for water increased at an unprecedented rate. Pulp and paper, mining, textile manufacture, and the chemical industry were among the fastest growing economic sectors. Each made use of enormous quantities of water. So did the profusion of new municipal water supply and sewerage systems in Canadian cities, and the expanding networks serving older municipalities.

In the west, important cities geared towards servicing the wheat-economy of the surrounding prairie grew up where trading posts had stood a hundred years earlier. Western agriculture was increasingly important to Canada's trans-continental economy. Particularly after the disastrous 1930s, more and more prairie farmers -- often aided by government agencies -- developed water storage facilities for purposes of irrigation. Western towns went to great lengths to secure the water supplies necessary for population growth and industrial development.

Discussion in this section will be organized around four themes. Firstly, the expanding role of the state in water development will be considered, with particular

attention to the multijurisdictional nature of water-management in the twentieth century. Secondly, the emergence of commercially viable hydro-electric power at the turn of the century, and the spread of electrical energy into factories and homes will be examined. A third theme is the expansion of industry -- particularly those industries making abundant use of water. Issues related to water quality will be raised here, although a full discussion of problems associated with modern industrial pollution is impossible. Finally, the emergence of the west as a centre of population and agricultural production, and the special needs of Canada's most water deficient region with respect to irrigation and water supply will be considered.

The State

In a sense, the growth of the state and of state influence in natural resource development embraces all the other trends isolated here. By "the state," I wish to refer to all three levels of government, and to associated public and para-public agencies.[1] The definition is substantially that of Leo Panitch, who suggests that

> . . . the state is not merely the government. The state is a complex of institutions, including government, but also including the bureaucracy (embodied in the civil service as well as in public corporations, central banks, regulatory commissions etc.), the military, the judiciary, representative assemblies and . . . the subcentral levels of government,

> that is, provincial executives, legislatures, and bureaucracies, and municipal government institutions.[2]

The growth of the Canadian state was a key twentieth-century trend and its impact on water-development was not inconsequential. Governments and their agencies proposed and implemented schemes to improve navigation, to develop hydro resources, to protect property owners from flood damage, to drain wetlands, to secure adequate water supplies for urban centres, to protect the resource against waste and pollution, to regulate interjurisdictional conflicts over water use, to develop and maintain recreation sites and to protect fish and wildlife against other (mostly human) water users. The complexity of the problem of water use in the twentieth century is reflected in the multiplication of agencies, commissions, authorities, and departments designed to deal with various aspects of it.

One early piece of Federal legislation -- the Northwest Irrigation Act of 1894 -- has already been discussed in an earlier section. It was suggested that this act established an important principle of Canadian water law: water rights were to be retained by the Crown and were made subject to license and regulation. In 1897, British Columbia defined its water-use policy in an act which incorporated this principle. This law was designed to update and supercede all previous laws "relating to the acquiring of water-rights and Privileges for ordinary domestic, mining and agricultural purposes." It was intended to make "adequate provision for municipal water supply, and for the application of water-power to

industrial and mechanical purposes . . . ." The law also dealt with the "mode of acquisition and enjoyment" of water privileges, and -- importantly for the Provincial treasury -- "the royalties payable to the Crown in respect thereof."[3]

In light of this and similar statutes, it is fair to suggest that the turn of the century marks the beginning of the serious regulation of the water resource by Canadian authorities. British Columbia's dependence on water power in mining, forestry and agriculture led that province to establish a comprehensive set of regulations concerning water-use at an early date.[4] Other provinces followed suit, particularly after the commercial possibilities of hydro-electric development had been demonstrated in the first decade of the twentieth century. Thus, in 1910, the Province of Quebec moved

> . . . to authorize the appointment of a commission to submit rules for the management of running waters . . . [such as] will reconcile the interests of agriculture, of industrial pursuits, and of the forests, with respect for the rights of property.[5]

Similar legislation was passed by Nova Scotia in 1914, by Ontario in 1916, by the Federal government in 1919 (Dominion Water Power Act), and by Saskatchewan and Alberta after they assumed control of their natural resources in 1930. J.H. Corry suggests that in each of these instances,

> . . . an administrative authority was authorized to make regulations governing the use of water, and to supervise and enforce compliance with the regulations.[6]

This sort of legislation reflects a new attitude in the seats of power. It shows a recognition of the fact that water -- like other natural resources -- is part of the public domain, and that its use, particularly for commercial and industrial purposes, has to be supervised and regulated for the common good.

As suggested earlier, the state used its authority (and its taxing powers) to stimulate activity in almost every area of water development in the twentieth century. Exhaustive coverage of these matters is not possible here. But it is relatively simple to isolate a number of areas in which state activity was conspicuous, and to briefly discuss important developments within each area.[7]

The Federal government retains its jurisdiction over inland navigation in Canada to the present day. Twentieth-century initiatives in this field have not always been successful, particularly because of the growing importance of alternative transportation systems -- such as rail, truck and air transport. The importance of a water-route between the Great Lakes and the head of ocean navigation on the St. Lawrence, however, remained an important issue until the completion of the St. Lawrence Seaway in 1959.

At the beginning of the century, it was by no means clear that this seaway would ever be built. An alternative scheme -- involving a deep waterway along the old fur-trade route from the Ottawa River to Georgian Bay -- was proposed by the Federal government in 1904. According to estimates made by the

Department of Public Works in 1908, such a waterway could be built over a period of ten years at a cost of $100,000,000.[8] One perceived advantage of this scheme was that it was an all-Canadian proposal; construction of a similar system along the St. Lawrence route would of necessity involve American participation. But the project was never built; Laurier's government was defeated in 1911 with the Georgian Bay Ship Canal as part of its electoral platform.

Flood control emerged as an area of state intervention in this period. One student of floods and flood control in Canada suggests that the federal interest in the issue was slow to develop because under the British North America Act, "the regulation of natural resource development" was designated as a provincial responsibility.[9] Although the central government may have been slow in developing policies for flood control and relief (at least prior to 1950) the "sub-central levels of government" were actively involved in flood-plain management. An example is the work of the Ontario Conservation Authorities, the first of which was established in 1946. These regional agencies were formed "on the basis of the watershed or drainage area of a stream or group of streams."[10] They set up conservation programs in all fields, and have been involved in channel improvement, the construction of by-pass channels, dikes and flood-walls, as well as in major upstream storage projects which have important recreational, water-supply and wildlife functions in addition to providing flood protection. Ontario Conservation

authorities have received generous support from Federal and Provincial agencies. Four upstream storage reservoirs on the Grand River, for example,were funded on the basis of the following distribution: 37.5% federal; 37.5% provincial; 25% local funds. These reservoirs, the Shand, the Luther, the Conestogo and the Guelph, were constructed between 1942 and 1976.

Public responsibility for flood-control, flood-relief and flood-warning programs made sense politically and economically. One American study -- perhaps oversimplifying -- states the matter in these terms:

> Flood control is instituted for the protection and benefit of the people. These programs are paid for the by people.[11]

The Canadian study cited earlier made a similar point in arguing that "flood losses give rise to recurrent demands for public action."[12] In fact, in most cases where Canadian cities have experienced serious flood damage (e.g. Vancouver, 1948, Winnipeg, 1950, and Toronto, 1954) subsequent and remedial construction programs have been implemented at the public expense.

While public responsibility is an accepted principle, there is today debate over methods of dealing with recurrent flooding. One recent trend is away from structural solutions -- such as dikes and upstream reservoirs -- and towards institutional arrangements. A recent study of flood control on the Grand River takes the following view:

> The flood plain serves a natural function in conveying and storing water during periods of high flow . . . .

> [The] problem relates . . . to the intensive use of flood-prone areas for residential, commercial, industrial, institutional, transportational and agricultural purposes. Thus, the conflict is one of human use versus hydrological use of floodplain land.[13]

From this perspective, the reorganization of land-use in flood-prone areas would be a useful supplement to the structural adjustments which have been used historically.

Conservation more generally has been a concern of the Federal government since 1909. The Canadian Commission of Conservation was active between that year and 1921, when its duties were taken over by regular government departments. The Commission's mandate was to take an inventory of the country's natural resources, to consider questions associated with waste in resource development, to make its information available to the public, and to provide the government with recommendations on these issues. While it was active, the Commission identified four areas in which state action was necessary. Firstly, it recognized the need to impose limits on the exploitation of resources (necessarily a state function since it invovled coercion in the form of licenses, fees and penalties). Secondly, the Commission recommended measures for the restoration of resources which had already been over-exploited. Such measures included reforestation programs and fish-hatcheries. The third area of government action was public education about the country's resources, and the fourth was scientific research. Research was a particularly important area because, in J.H. Corry's terms,

> . . . the will to conserve and the exercise

> of public power to enforce that will, are likely to be misdirected and largely futile in the absence of exact knowledge of what to do.[14]

Municipal governments in this period were primarily concerned with securing adequate water supplies for their industrial and residential needs. Further attention will be paid to this important issue when discussion turns to the expansion of the west as a centre of agricultural production and population in the first half of the twentieth century.

Another area of government activity related to water use in the twentieth century was the regulation of boundary waters. The geographical extent of Canada's water-boundary with the United States has been evoked in a recent study:

> Along the 8,900km (5,500 miles) Canada-United States boundary, 3,900 km (2,400 miles) are formed by boundary waters. Along the remaining, less liquid portion of the boundary, some 90 significant rivers flow across the border . . . [15]

The establishment of an international body to deal with matters related to boundary waters was accomplished in 1909. That year marked the signing of the Boundary Waters Treaty with the United States. Negotiations leading to this treaty took place at a time when several water-related issues were clouding Canadian-American relations. One major problem was the reduction in the levels of the Great Lakes caused by the Chicago Drainage Canal, which diverted water from Lake Michigan in order to flush organic waste from Chicago's meat-packing industry down through the Mississippi system. Other problems concerned developments for purposes of power -- particularly at Niagara

Falls and Sault Ste. Marie -- and for irrigation -- particularly on the St. Mary and Milk rivers on the Alberta / Montana border.

The treaty, which was signed after protracted negotiations, contained general principles for the management of boundary waters. It also established the International Joint Commission, composed of three American and three Canadian members, to administer and enforce the treaty and to arbitrate disputes. This agency is regarded as one of the most successful policy instruments in Canadian water history. In 1958, an authoritative study of the I.J.C. was able to assert that

> . . . For almost half a century, . . . [Canada and the U.S.] have successfully used the International Joint Commission as the instrument for the prevention and settlement of disputes in regard to boundary and trans-boundary waters.[16]

And two Canadian water managers asserted in 1979 that

> Because of the Boundary Waters Treaty and the functioning of the International Joint Commission, it has often been easier to resolve international than interprovincial problems.[17]

Some further attention to the St. Lawrence Seaway seems appropriate, since it was perhaps the single most important water-related project of this period. The Seaway is doubly significant insofar as it exemplifies a new trend in water-development: the emergence of the major multi-purpose project.

The idea of a deep waterway to connect Montreal and the Lakehead was a logical extension of nineteenth century commercial capitalism. Shipping interests believed they could offer cheaper rates on grain transport than the railways with which they competed. But to do so, ocean-going ships drawing twenty to

thirty feet of water had to be able to ascend the St. Lawrence to the Great Lakes ports -- including Chicago, Detroit and Duluth. Montreal "merchants" still coveted the grain traffic of the west, which now constituted a vast, agriculturally productive region which had been largely unsettled in the nineteenth century.

Ironically however it was not western wheat which provided the stimulus for the construction of the Seaway in the 1950s. The economic argument which ultimately brought victory to the pro-seaway forces was that two of Canada's new "staple products" -- iron ore and hydro-electric power -- could be developed more effectively with a deep waterway in place. Iron ore, which had been discovered in abundance in the Quebec - Labrador trough, could be carried by rail to ports on the North Shore of the St. Lawrence, and from there, via the Seaway, to steel mills at Hamilton, Cleveland, Gary and Chicago. The importance of hydro-development to the seaway project is reflected in the fact that $180 million more was spent on hydro facilities than on navigation improvement.[18]

Built with the cooperation of Canadian and American authorities, the seaway provided vastly improved navigation:

> Ships carrying up to 28,000 tons of bulk cargo and vessels carrying up to 9,500 tons of general cargo, provided they did not draw more than 25 feet 6 inches of water, could travel in easy stages from the Port of Montreal to the head of the Great Lakes, over 600 feet above sea level, lifted . . . by massive locks 900 feet long (766 feet of usable length) and 80 feet wide.[19]

As suggested earlier, the seaway combined navigation with other uses -- particularly hydro-electric power generation. The recreation potential offered by power pools such as Lake St. Lawrence, however, has to be weighed against the social costs of this type of wholesale flooding. When in 1958, 20,000 acres of Ontario land were inundated to create this reservoir, 6,500 people living in 8 communities and on 225 farms were forced to evacuate their homes, some of which had been in their families for generations.[20]

Hydro Development

This section serves as a bridge between discussions of the increased importance of the state in water development, and the growth of industry and its use of water in the twentieth century. This is appropriate, since hydro-power was an important area of state-intervention, as well as a crucial factor in Canada's twentieth-century industrialization.

Most Canadian provinces have rivers and streams which are capable of being developed for the purpose of generating electrical energy. In his Presidential address to the Royal Society of Canada in 1899, the engineer T.C. Keefer made substantially this point, if in different terms:

> An examination of any good map of our broad Dominion, reveals, as its most striking feature, an extraordinary wealth and remarkable uninterrupted succession of lakes and rivers, suggestive of ample rainfall, the first great requisite in the occupation of any country. Over a length of several thousand miles, between Labrador and

> Alasksa, and over a width of several hundred miles, there is an almost continuous distribution of lakes; lakelets and rivers; the lakes of varied outlines, dimensions and elevations above sea level, and many possessing facilities for the storage of their flood waters. In many places the outlet from the lake or the connection between a chain of lakes is a narrow cleft in rock where an inexpensive dam will hold back the water supplied by the winter's accumulation of snow.[21]

Development of these "water powers" began in the first decade of the twentieth century. A point made earlier is that individual provinces moved quickly to ensure control over their water resources once the commercial and industrial potential of this new technology had been ascertained.[22] The 1914 Nova Scotia statute cited earlier (page 90) was in fact entitled "An Act respecting the Development of Water Powers within the Province," and was designed primarily to oversee "the flow, the drawing off, the disposal, the distribution, [and] the storage" of Nova Scotia's surface waters.[23] These regulations were necessary because of the technological advances which had made white water an extremely valuable resource, and therefore subject to over-exploitation.

As Keefer suggested, much of Canada's potential hydro-electric power was located on the Laurentian shield. For this reason, and because the story is intrinsically interesting, it is useful to compare and contrast (if only briefly) the histories of hydro-development in Ontario and Québec.

The principle distinction to be made between early hydro development in Ontario and Québec is that while Ontario's

power system developed from the outset as a public utility, the electric industry in Québec was dominated by private corporations until the "Quiet Revolution" of the 1960s. Prior to 1907, water-power sites in Québec were alienated by outright sale, often at very low prices. J.H. Dales suggests that this was because hydro-electric development was still a speculative venture in this early period, insofar as its profitability had not yet been demonstrated.[24] In the Saguenay and St. Maurice basins, important water-power sites were sold to private developers -- such as the Shawiningan Power & Light Co. and the Laurentide Pulp Co. -- for prices ranging from $5,000 for a site at Grand-Mère to $60,000 for the right to generate power at Shawiningan Falls. Dales suggests that

> Similar grants were made on the Upper Ottawa, while lumber interests obtained title to many power properties on the Gatineau and Lièvre rivers, most of these having been used for lumbering purposes for many years previously.[25]

After 1907, power sites were leased, not sold by the Québec government. But private corporations continued to be the main developers. In 1929, 7 large power companies controlled 98% of the developed power in the province.[26]

By way of contrast, the creation of the Ontario Hydro-Electric Commission in 1906-7 by a special act of the provincial legislature marks the beginning of hydro-electric development in Ontario. Ontario Hydro has been called

> . . . one of the world pioneers in large-scale hydro-electric development, standardi-

> zation of equipment and appliances, utility management and rural electrification.[27]

The early development of a provincial hydro-commission allowed

> . . . a small number of municipalities in the western part of the province to cooperate in financing the purchase, transmission, distribution, and sale at cost of electrical energy generated at Niagara Falls, approximately a hundred miles away.[28]

The initial capital of the commission was $2,500,000, and it had built its first transmission line by 1910. The number of municipalities served increased from 12 in 1910 to 130 in 1915. Further expansion brought hydro power to 263 communities in 1920, 436 in 1925 and 550 in 1928.[29] In 1960, Ontario Hydro's fixed capital was $2.5 billion, and its dependable capacity was over 6 million kilowatts.[30]

Ontario's early adoption of the principle of provincially owned electrical utilities set an example which was to be followed by the rest of the provinces as the twentieth century progressed. Once the importance which electric energy would have for the modern economy became apparent, it became essential to standardize power frequencies and to integrate transmission lines, so as to achieve maximum benefit from the resource. This could best be accomplished by a public utility.

Electricity of course, has become an important part of day to day life in Canada in the period since 1900. Early uses were primarily industrial and municipal. Pulp and paper plants in particular were quick to develop the electrical

potential of rivers, especially in Quebec, Ontario, New Brunswick and British Columbia. Ontario Hydro served municipalities whose main concern was with street lighting. It took a long series of technical innovations to turn electrical energy into the familiar, multi-purpose commodity used so extensively by Canadians today.

Industry

It has been suggested that industrial growth was among the most important trends of the first part of the twentieth century. Two historians of the period 1896-1921 offer some statistics which confirm this observation. Between 1900 and 1923, the net value of production in all Canadian manufacturing industries increased from $214 million to $1.3 billion, a six-fold increase.[31] Economic growth would continue in the period under review, although it was to be interrupted by the Depression of the 1930s.

Canadian industrial growth was not limited to any one sector, though certain key industries had emerged by the first decade of the twentieth century. These included wood and wood products (including pulp and paper), minerals (particularly iron), textile manufacture, the chemical industry, rubber products, tobacco, and the boot and shoe industry. In the period 1900 to 1923, the fastest growing manufacturing industries were iron and iron products, for which the net value of production increased from $35 million to $209 million, chemicals and chemical products ($4 million

to $57 million) and electric light and power ($2 million to $67.5 million).[32] Growth in this period was spurred by the rising tide of industrial consolidation (the year 1910 alone saw 22 mergers, capitalized at $157 million) and by the "gradual change from coal and steam power to electricity as the driving force for factory machinery."[33]

Industrialization, as in the nineteenth century, led to intensified urbanization. Between 1891 and 1921 the populations of Canada's two largest cities, Montreal and Toronto, more than doubled. Out west, Winnipeg and Vancouver increased their populations five-fold on the strength of the wheat boom, and other important centres appeared out of nowhere. Early twentieth century cities tended to be a study in contrasts. In Montreal, "the city below the hill" lacked adequate sanitation facilities, hydroelectricity, telephones and other amenities which were commonplace in the wealthier districts on the slopes of Mount Royal. In many industrialized cities, extreme poverty prompted the emergence of municipal reform movements. In Toronto, for example, public health measures were undertaken, including "the establishment of public baths, installation of a sewage treatment plant and a filtration plant and extension of the sewer system."[34]

Canadian industry expanded its already substantial use of water in the twentieth century. The pulp and paper and the mining industries were among the many which depended heavily on hydro-electric power to run their equipment. The

Canadian Department of Mines conducted an inquiry into the "Industrial waters of Canada" between 1934 and 1940. Its conclusions give an impression of the widening scope of industrial water use in twentieth-century Canada:

> Water is the most important of all mineral resources since life cannot, and few industries, if any, can function without its aid. Among its many uses in industry may be mentioned the following: a solvent in chemical processes, such as soap manufacture, dyeing, fermentation, manufacture of sugar, tanning, in the manufacture of textiles, pulp and paper, and in baking; in ore dressing as a vehicle for the conveyance of pulped material; for cleansing; for cooling; for distribution of heat and power, either thermo-dynamic or hydraulic; fire extinguishing . . . .[35]

The results of these investigations were published in 1942 and constitute a good source for the study of industrial water-use in mid-twentieth century Canada.

The Department of Mines report was directly concerned with the quality of Canadian waters, not because of environmental concerns, but because dissolved or suspended materials in water could cause operating problems for manufacturers and resource extracting industries, thereby increasing production costs.

Interestingly, the authors of this report seem to have anticipated problems which would later be described as acid rain, although they were not concerned with the potential impact on the environment. In a section entitled "Impurities in Natural Waters and their Origin," the report suggests that although rain water is the purest water available,

> . . . many rain water are far from pure . . . Drops of rain falling through the atmosphere absorb matter in amounts depending largely upon the locality and its influence on the purity of the atmosphere. Above large manufacturing areas the air is often laden with dust of all kinds, soot, silica, silicates, sulphates and carbonates, sulphuric and sulphurous acid, hydrogen sulphide, ammonia, organic matter, etc. These are adsorbed in the falling rain or snow, resulting in a very inferior water . . . . Even in places where there is no factory pollution of the air, . . . the rain water shows appreciable amounts of dissolved and adsorbed matter.[36]

Again, the investigators'concern is with the purity of water as it affected manufacturers' interests -- since water with particular characteristics was needed in specific industrial processes -- and not with environmental matters.

Certain industries in the Canadian economy were particularly dependent on the water resource. In the growing chemical industry, water was used in a variety of processes. In the mining industry, enormous quantities of water were used in the ore concentration porcess, as "the main agent for separating the precious metals and the more valuable ores from their gangue." The 1942 report suggested that a single ore concentration plant in western Canada used 3.2 million gallons of water each day. Chemicals added in the flotation process made five-eighths of the water thus withdrawn unfit for re-use, and it was discharged back into the environment.[37]

The pulp and paper industry was one of the country's heaviest water users in this period. Water was used "in the processes for the conveyance and distribution of pulped material, for cleaning, heating and as a solvent." The

purity of the water used was important to the quality of the finished product:

> . . . highly coloured waters . . . impart a yellowish tint to the product. If very white paper is required, the higher price obtained for the product may well pay for the treatment of the process water.[38]

In the textile industry, water was important in the processes of de-gumming, washing and dyeing. Large quantities of water were also used in the production of felt hats, soap, beer and distilled spirits, leather products, sugar, canned and baked goods, starch and glue.[39]

Clearly, water was essential to Canada's industrialization in the twentieth century. In the 1940s, industrial growth meant "progress", and few were yet aware of the ecological threat posed by the industrial use of Canada's water resource. Concerns about water quality were expressed from a utilitarian perspective; acidic water, for example, was only seen as a problem insofar as it might tend to promote corrosion and "acid steam" in manufacturers' boilers.[40] Awareness of the environmental impact of industrial water use has only emerged in the last twenty to thirty years.

The West

Canada's prairie region emerged as an important centre of population and agricultural production in the first quarter of the twentieth century. The basis of the expansion was a single commodity: wheat.

As the prairies filled up with settlers attracted by cheap homesteads and fertile soils, Canadian wheat production and export soared. According to Brown and Cook,

> In 1896 wheat production in Canada stood at 7,855,274 bushels. Five years later it had jumped to 26,117,530 bushels and a further threefold increase had taken place by 1911. Though the 1918 and 1919 crop years were extremely poor, total wheat production had risen to nearly 151 million bushels by 1921.[41]

In order for this type of expansion to occur, western settlers had to overcome problems associated with water supply, both for agricultural and municipal use. In the early settlement phase the shortage of surface water in the prairie region had already become apparent. George Spence suggests that the same was true for ground water supplies:

> In many localities, on the open plains, wells were few and far between. Often, too, when water was struck in deep wells, the water was so highly mineralized as to be unfit for human use, or even for stockwatering purposes.[42]

Despite these problems, the prairie region filled up rapidly, and important cities grew up as service, commercial and manufacturing centres for the prairie wheat economy.

Western cities such as Winnipeg were forced to go to great lengths to secure adequate water supplies for their growing populations. Between 1906 and 1913, the problem of securing a permanent water supply occupied much of the Winnipeg City Council's attention. In 1907, the use of Shoal Lake water was first suggested. This source was considered "excellent . . . for domestic, boiler and general manufacturing

purposes,"[43] but was located some 130 km to the east of the city. The decision to use Shoal Lake required the approval of the Manitoba and Ontario provincial governments, as well as that of the International Joint Commission. This is because Shoal Lake is an arm of the Lake of the Woods, which straddles the Canadian - U.S. border at the junction of Ontario and Manitoba.

The Saskatchewan cities of Regina and Moose Jaw had particularly severe water shortages in the early part of the century. The period between 1917 and 1921 saw drought conditions strike southwestern Saskatchewan and southern Alberta. According to Spence,

> Sizeable lakes and streams went bone dry, shallow wells gradually dried up, and in some districts water had to be hauled in railway tank cars to supply domestic and stockwatering needs.[44]

These conditions brought about efforts on the part of the citizens of Moose Jaw and Regina to secure a reliable water supply, not least as a means of protection against fires. Meetings were held in Moose Jaw in 1919, and representations were made to the Provincial government on behalf of the two major cities and 16 other communities in this water-short region. The substance of the proposals involved the diversion of enough water from the South Saskatchewan River to supply the domestic and agricultural needs of the area. Although a Provincial commission was appointed to investigate the proposed diversion, no action was taken at this time. Development of the South Saskatchewan River for purposes of improved

regional water supply and irrigation would have to wait until the 1960s.

In a drought-prone area such as the prairies, the irrigation of agricultural land is a high priority. Smith's history of irrigation in Alberta traces three distinct pahses in the development of irrigation in the twentieth century. In an initial "commercial phase," lasting from the 1890s to 1915, most irrigation was undertaken on behalf of railway companies which had been given substantial land grants as a means of financing construction of their lines, and which were in a better position to attract settlers (and hence revenue) if their lands were irrigated. The second, or "district" phace is dated from the passing of the Irrigation Districts Act in 1915. This act gave irrigation districts "quasi-municipal powers;" most importantly, it allowed them to issue debentures as a means of financing irrigation works, which were increasing in complexity by this time. In the 1920s and 1930s, only very small irrigation ventures were able to survive without some form of government assistance. Smith dates the third phase of Alberta's irrigation development from the end of World War Two. By this time, irrigation was firmly ensconced as a public responsibility:

> . . . By 1955, all irrigation in Alberta was either administered as irrigation districts or Crown corporations administered by the Province, . . . [except] the Canada Land Project at Vauxhall, which had been taken over by the Federal Government.[45]

In Saskatchewan, early irrigation development developed

more slowly than in Alberta. Part of the reason was that private land development companies were unwilling to invest in the heart of the Palliser triangle. Only a few small irrigation works had been developed in the province prior to the 1930s.

The severe drought and collapsed market conditions of the Depression years took their heaviest toll in the province of Saskatchewan. Accroding to the Rowell-Sirois report, issued in 1940,

> Canada's most serious economic troubles during the thirties had their origin in the impact of the world depression and drought upon the wheat-growing industry of Saskatchewan . . . . The area affected by successive crop failures was about equal to one-quarter of the total improved farm acreage of Canada. It contained nearly one half of the rural inhabitants of Saskatchewan. In 1931, one-half; in 1933-4-6, one-third; and in 1937, two-thirds of the total farm population of the Province was destitute.[46]

In the midst of this calamity, the federal and provincial governments took steps to alleviate its worst effects. The most significant measures -- beyond the short-term relief which enabled the people to survive -- were those which looked towards the reorientation of prairie agriculture. The establishment of the Prairie Farm Rehabilitation Administration by the Dominion government in 1935 was such a measure. The P.F.R.A. was empowered to design and implement programs in three areas -- cultural practice, land utilization and water conservation -- with a view toward preventing the sort of catastrophe that crushed the prairie economy in the thirties.

Acting within its water-conservation mandate, the P.F.R.A. had "provided engineering and financial assistance toward the construction of upwards of fifty thousand small dams and dugouts for the conservation of spring run-off waters" by 1952.[47] In south-west Saskatchewan alone, the P.F.R.A. had developed 26 storage reservoirs and six irrigation projects, serving 9, 310 hectares of hay and fodder crops, at a cost of $4.7 million by 1982.[48] Clearly this type of initiative, while not eliminating the threat of drought on the prairies, can go a long way towards mitigating its effects.

To conclude, the twentieth century has seen a tremendous increase in the scale and complexity of water use in Canada. State agencies have emerged to protect and develop the resource, and to arbitrate disputes between potential users. Industrial uses have multiplied, as have the needs of municipal systems serving vastly expanded communities. Water quality is today threatened by a wide range of pollutants in all regions of Canada. Rivers and streams are diverted, dammed, and otherwise controlled on a huge scale to serve a wide variety of interests, from urban flood control, to irrigation, to hydro-electric development. In the wake of demographic growth, industrialization and urbanization, and territorial expansion, the story of Canadian water has travelled far from its origins in the last Ice Age. The birch canoes and stone fishing weirs of native society, and the simple water mills used by the first European settlers to grind grain and saw boards seem

a long way off indeed. And yet, native peoples still depend on natural regimes and qualities to maintain their traditional economies and lifestyles.

Notes to Section 6

1. Further and more specific attention to developments at the federal level is contained in Section 7.

2. Leo Panitch, "The Role and Nature of the Canadian State," in Panitch, ed., *The Canadian State: Political Economy and Political Power* (Toronto and Buffalo: University of Toronto Press, 1977) p. 6.

3. Statutes of British Columbia (1897) cap. 190.

4. J.H. Corry, "The Growth of Government Activities since Confederation." Paper prepared for the Royal Commission on Dominion-Provincial Relations (Ottawa, 1939).

5. Statutes of Quebec (1910) cap. 5.

6. Corry, *Op. Cit.*, p. 152.

7. A very conspicuous area of state activity, hydro development, will be considered in a separate section.

8. Canada, Department of Public Works," Georgian Bay Ship Canal: Report upon Survey, with Plans and Estimates of Cost, 1908," (Ottawa, 1909) p. xix.

9. Ian Burton, "Flood Damage Reduction in Canada," *Geographical Bulletin* 7 (1965) p. 163.

10. Ontario, Ministry of Lands and Forests, *Annual Report* (1962).

11. L.B. Leopold, T. Maddock, *The Flood Control Controversy: Big Dams, Little Dams and Land Management* (New York: Ronald Press Co., 1954) p. 95.

12. Burton, *Op. Cit.*, p. 162.

13. Bruce Mitchell et. al., "Physical Adjustments and Institutional Arrangements for the Urban Flood Hazard in the Grand River Watershed, Ontario," *Canadian Water Resources Journal* 3:2 (1978) p. 35.

14. Corry, *Op. Cit.*, p. 145.

15. James P. Bruce and Frank J. Quinn, "What Difference do Boundaries Make?" *Canadian Water Resources Journal* 4:3 (1979) p. 5.

16. L.M. Bloomfield, G.F. Fitzgerald, *Boundary Waters Problems of Canada and the United States: The IJC, 1912-1958* (Toronto: The Carswell Company Ltd., 1958) pp. iii-iv.

17. Bruce & Quinn, *Op. Cit.*, p. 4.

18. R.E. Richardson et. al., *Developing Water Resources: The St. Lawrence Seaway and the Columbia / Peace Power Projects* (Toronto: Ryerson / MacLean-Hunter, 1969) pp. 3-4.

19. *Ibid.*, p. 2.

20. *Ibid.*, p. 23.

21. Quoted in H.G. Acres, *Water Powers of Canada: The Province of Ontario* (Ottawa: Department of the Interior, 1915).

22. As did the Federal Government as regards water powers on Crown lands.

23. Statutes of Nova Scotia (1914) cap. 8. The corresponding Ontario statute, passed in 1916, was entitled, "An Act to regulate the use of the Waters of the Province of Ontario for Power Development purposes." "Power" was defined so as to include "hydraulic, electrical, or pneumatic power or energy." Statutes of Ontario (1916) cap. 21.

24. J.H. Dales, *Hydroelectricity and Industrial Development in Quebec, 1898-1940* (Cambridge: Harvard University Press, 1957) p. 30.

25. *Ibid.*, p. 31.

26. G.W. Stephens, *The St. Lawrence Waterway Project* (Toronto: Warwick Brothers & Ruther, 1930) p. 347.

27. Merrill Denison, *The People's Power: The History of Ontario Hydro* (Toronto: McClelland & Stewart, 1960) p. [illegible].

28. *Ibid.*

29. Stephens, *Op. Cit.*, p. 346.

30. Denison, *Op. Cit.*, p. 2.

31. R.C. Brown and Ramsay Cook, *Canada, 1896-1921: A Nation Transformed* (Toronto: McClelland and Stewart, [illegible]) pp. [illegible].

32. _Ibid_.

33. _Ibid_., p. 10.

34. _Ibid_., p. 102.

35. Canada, Department of Mines, "Industrial Waters of Canada: Report on Investigation, 1934-1940" (Ottawa, 1942) p. 33.

36. _Ibid_., p. 18.

37. _Ibid_., p. 22.

38. _Ibid_., p. 24.

39. _Ibid_., pp. 25-31.

40. _Ibid_., p. 31.

41. Brown and Cook, _Op. Cit_., p. 53.

42. George Spence, _Survival of a Vision_ (Ottawa: Department of Agriculture, 1967) p. 15.

43. City of Winnipeg, Brief presented to Inquiry on Federal Water Policy, September 1984.

44. Spence, _Op. Cit_., p. 43.

45. R.F. Smith, "History and Current Status of Irrigation in Alberta," _Canadian Water Resources Journal_ 3:1 (winter 1978) pp. 10-11.

46. Canada, Report of the Royal Commission on Dominion - Provincial Relations (1940), Book 1, p. 169.

47. Canada, Report of the Royal Commission on the South Saskatchewan River Project (1952) p. 123.

48. H.L. Topham, "History of Irrigation in Western Canada" (Calgary: Prairie Farm Rehabilitiation Administration, 1982) n.p.

Section 7:
The Federal Role: Some Historical Background

Canada's federal government has had an important role to play in the development and regulation of the country's water resources. Even prior to Confederation, the government of the United Canadas took an active part, particularly in the areas of fisheries and navigation. Fisheries was a field where a good deal of state regulation was necessary, since unchecked overfishing could do irreversible damage to an important economic resource -- as it already had in some areas. Accordingly, by the Fisheries Act of 1857, this responsibility was vested in a special fisheries branch of the Department of Crown Lands. By the terms of this act, Fisheries Superintendants were appointed in both Upper and Lower Canada; Overseers of Fisheries also assumed certain administrative functions and a licensing system was adopted. Conditions remained unsatisfactory, however, in the maritime colonies, which were not as yet part of Canada and were not, therefore, affected by the legislation.

The recognition of the need to regulate the fisheries in Canada was in part a product of the advances in scientific knowledge of the later nineteenth century. One source credits a small number of federal civil servants -- experts in their field -- with providing the impetus for the 1857 Fisheries Act: the first substantive effort to offset "the crass spoliation of our great fisheries resource." One such

official was Richard Nettle who drafted the basic Fisheries Act, and who was among the first Canadian scientists to successfully propagate fish under artificial conditions. He wrote widely on fisheries and their conservation, and his 1857 book on the St. Lawrence salmon fishery was particularly influential. Canada's first fish hatchery was probably located in the Crown Lands Department, in a room adjoining his office. The importance of expert scientific advice to federal policy-makers -- in this case as regards the fishery -- had already been established by the 1850s.

Fisheries legislation, of course, did not end with the Act of 1857. After Confederation, a new Department of Marine and Fisheries was constituted at the federal level, and charged with administering the Dominion's responsibilities in fisheries and navigation, as outlined in the B.N.A. Act. The new department consisted of two distinct branches with separate responsibilities, but accountable to a single minister. The fisheries branch was charged with the enforcement of laws with respect to fisheries, while the marine branch had a series of duties related to navigation which will be discussed below. In 1884, these two branches separated, so that a distinct Department of Fisheries existed between 1884 and 1891; in 1892, the departments were again united, for purposes of economy. Two more changes carry this administrative outline through until 1930, when the Fisheries Department Act created a Fisheries Department which was to endure until 1969. In 1914, the fisheries branch was incorporated into the Department of

Naval Service, and in 1921 the old Department of Marine and Fisheries was reconstituted.

What did these various incarnations of a fisheries department (or branch) do? It is clear that the establishment and enforcement of measures for the conservation of the resource was their primary function. J.H. Corry states the matter in broad terms when he suggests that "The Fisheries Act of 1868 provided for a substantial amount of regulation and authorized the appointment of fisheries officers with powers to enforce the legislation."[2] Corry also suggests, however, that early enforcement of the Fisheries Act was lax: something he attributes to a lack of scientific expertise among fisheries officers. In 1892, a scientifically trained Fisheries Commissioner (the post had been created in 1873) was appointed. From this point onward, the knowledge of effective means of conservation, the observed need for strict controls, and the suitability of federal measures increased.[3]

In addition to enforcing regulations and issuing licenses, the federal government became involved in fish replenishment programs in the nineteenth century. Nettle's early fish hatchery has already been referred to. Corry suggests that this type of activity expanded greatly after 1892, largely because of the Commissioner's interest in marine biology. By 1931, there were 23 federally run fish hatcheries in Canada, as well as 9 subsidiary hatcheries and 8 salmon retaining ponds.[4]

In 1889 the fisheries branch took on a further responsibility.

In that year, the Fisheries Intelligence Bureau began collecting and distributing information on fishing conditions across Canada to interested parties. The information was collected at 52 stations across Canada, reported to a central station in Halifax, and distributed from there via telegraph to business centers concerned with fishing.

A final issue concerning the fishery is perhaps the most important in terms of practical public policy. This involves the (historically) ambiguous distribution of power between the federal and provincial levels where this resource is concerned. According to the interpretation of the B.N.A. Act which prevailed in the nineteenth century (1867-1898), "both the regulation and administrative control of all fisheries of the Dominion" was vested in the federal government.[5] Subsequently, however, questions arose as to the Dominion's power to grant exclusive fishing rights in the non-tidal portions of rivers. A decision by the Exchequer Court of Canada determined that the ownership of fisheries in non-tidal waters lay with the riparian owners; provincial governments were therefore able to claim administrative jurisdiction in their respective waters.

These issues -- which represent an early example of federal / provincial conflict over the control of an important resource -- were not resolved in Canada. Three separate court cases were taken to the Privy Council before general principles for the distribution of powers in the administration of the fishery emerged. M.V. Higgins has summarized the results

of this litigation, which took place in 1898, 1912, and 1920. Firstly, the provinces were to retain whatever riparian property rights they held prior to Confederation. Secondly, the federal government was to hold exclusive jurisdiction over a public right of fishery which applied to all tidal waters and, in the case of Québec, all navigable waters accessible by navigation from the sea. Finally, and most importantly from the provinces' perspective, the federal government retained the right of regulation of inland fisheries, but the provinces were granted administrative jurisdiction. J.H. Corry states the situation at the turn of the century in somewhat simpler terms:

> . . . In the meantime, the Dominion lost, through constitutional interpretation, the power to administer and enforce its own regulations over the inland fisheries. The provinces had been much dissatisfied with Dominion administration, which was thought to be wooden and unresponsive to local conditions and needs. Accordingly, when they secured a restrictive interpretation of Dominion powers, they began to move into the field. Not only were they entitled to manage the enforcement of the Dominion regulations respecting inland fisheries, but provincial proprietorship of these fisheries enabled them to establish a variety of regulations of their own . . .[6]

The ambiguity which prevails in current federal / provincial relations over fisheries has its roots in these events. The distinction between regulatory and administrative jurisdiction -- enshrined by the high court in London -- seems arbitrary and impractical. As one historian put it, using a quaint turn of phrase,

> The decision of the Privy Council . . . that the province had proprietary rights in the fisheries, but that the Dominion had legislative jurisdiction, implying power to affect those proprietary rights, and that both authorities had the right to levy a tax or license, made confusion worse confounded . . .[7]

Navigation is another water-related area in which the Canadian central government has played an important role since prior to Confederation. Indeed, the great canal-boom of the 1840s -- though financed by Imperial loans -- was planned and implemented by the Board of Commissioners of Public Works of the United Province of Canada. By 1867, the Board -- which became the Department of Public Works of the United Canadas in 1859 -- had expended approximately twenty million dollars, much of it for the development of the canal system discussed earlier.

The role of the Department of Public Works, especially in the construction of aids to navigation, can now be outlined. Attention will then be turned to the other departments which held responsibility in the area of navigation, namely Fisheries and Marine and Railways and Canals. Finally the water-related activities of the department of the Interior will be examined.

As constituted by a federal act on December 21, 1867 , the Department of Public Works was

> . . . made responsible for all public works not under the supervision of the provinces, such as canals, harbours, construction of lighthouses, military and inter-provincial highways, railways etc. . . .[8]

This was a slight departure from the pre-Confederation situation, since "control of most roads and bridges and certain public buildings" had been transferred to the provinces, and since the department's mandate was now extended to cover works in the maritime provinces.[9] In 1868, administration of harbours, piers, lighthouses, beacons and buoys was taken over by the new Department of Marine and Fisheries, although Public Works retained responsibility for their construction.[10] With the expanded importance of railways in the 1870s, it was seen fit in 1879 to create an embryonic Department of Transport -- known at this stage as the Department of Railways and Canals. Public Works ceded responsibility for the management of canals and related works to the new department at this juncture. As before, however, it maintained responsibility for the construction of such works, and for the important engineering studies and geological surveys which must precede any such construction.

From Confederation to the turn of the century, then, Public Works lost many of its administrative functions to more specialized departments, but retained its role in the area of construction. An outline of the federal administration written in 1914 gave a summary of Public Works' responsibilities. In addition to the construction and maintenance of public buildings, and of telegraph lines on government lands, the department was in charge of

> . . . the plant employed in the construction, improvement and repair of harbours, piers and works for the betterment of navigation . . . [and]

> the slides, dams, piles etc. used
> for facilitating the transmission
> of timber . . .[11]

Public Works was one of the five great spending departments of the federal government at the turn of the century.[12] Its total expenditure in 1910, for example, was twelve million dollars, of which the bulk was spent not on major engineering projects, but in small amounts to fill local needs such as the dredging of a harbour or the repair of a wharf.[13] This is not to suggest that Public Works was not still involved in major projects. It certainly was, and several important examples can be cited here. Between 1887 and 1895 Public Works built a lock at the Poupore Rapids on the Lièvre River, an important logging tributary of the Ottawa. The provision of means 'for facilitating the transmission of lumber' was part of the department's mandate, as outlined earlier. The navigation aided by this lock "was naturally confined to tugs and other vessels used for logging" as Robert Leggett wrote in 1976.[14] In 1956, the lock was sold to the James MacLaren Company, a major local paper concern.

On the Red River, the wide variation in stream flow had been the cause of periodic flooding in the City of Winnipeg, the ultimate response to which would be the construction of a floodway around the eastern limits of the city. Navigation as well was adversely affected by the wide variation in water levels. Accordingly, the Federal Department of Public Works constructed "a combined facility including a control dam, a navigation lock, a fishway and a highway bridge."[15] Built

between 1900 and 1916, the facility is known as St. Andrew's lock, and currently accommodates some 1500 small pleasure craft, as well as 300 tugs, barges and larger pleasure craft per year.

Finally, the role of the Department of Public Works in the elaboration of plans for what Leggett calls "the Great Dream" -- the Georgian Bay Ship Canal -- can be mentioned. The main contribution of the department was the detailed survey begun in 1904 and completed in 1908, the report of which is cited elsewhere in this text (section 6, note 8). The survey cost about double the original Parliamentary authorization of $250,000, and demonstrated the feasibility of an Ottawa River - Georgian Bay deep waterway from an engineering perspective. Since the waterway was never built, however, it is difficult to agree with Leggett when he writes, ". . . never was public money better spent."[16]

The twin functions of the Department of Marine and Fisheries, established in 1868, have already been mentioned. As suggested, the marine branch of the department had a series of duties related to navigation in Canada, some of which it had acquired from Public Works. Captain Ernest Chambers has written a history of the department, in which he lists the responsibilities of both branches. Those related to navigation were

> . . . Trinity Houses, Trinity Boards, Pilots, Pilotage, Decayed Pilots' Funds, Beacons, Buoys, Lights and Light-houses and their maintenance, Harbours, Ports, Piers, Wharves, Steamers and Vessels

> belonging to the Government of Canada, except gun-boats and other vessels of war, harbour commissioners, harbour masters . . . and generally such matters as refer to the marine and navigation of Canada.[17]

A similar account is given by Sir Joseph Pope in his discussion of government organization in 1914. This author suggests that in addition to his responsibility for the fisheries,

> . . . the Minister of Marine and Fisheries supervises the construction of lighthouses and fog alarms; maintains lights, buoys and other aids to navigation; regulates marine hospitals, the inspection of steamboats; the examination of masters and mates, pilotage and inquiries into wrecks . . . .[18]

These were important duties in an age when, in certain quarters at least, railways were still considered a supplement to water-based transportation.

The rapid growth of the Department of Marine and Fisheries can be estimated by examining its expenditures over the period 1868-1905. The department spent a total of $371,000 in its initial year of operation, 1868. This sum more than doubled over the next nine years to reach $786,000 in 1879. The increases of the next twenty years were inconsequential, perhaps because of the gains made by rail transport in the period. However the first six years of the twentieth century saw departmental expenditures increase from approximately $1 million in 1900 to $5.7 million in 1905.[19] It is difficult to assess these increases without noting that the years between 1896 and 1911 were years of economic boom in Canada - a boom predicated on the expanding western wheat staple, for which adequate transportation links were essential.

On the issue of harbours, there was occaional friction between local interests and the Department of the Marine, which had been responsible for their maintenance since 1868. According to J.H. Corry,

> In the larger harbours, the older method of administration by local harbour master under the loose supervision of a central department soon gave way to management by a harbour commission composed of local people but directly supervised by the Department of Marine.[20]

In Corry's terms, this system was unsatisfactory from the federal perspective because "local pressures interfered with administration in the national interest." Accordingly, when in 1931 Sir Alexander Gibb investigated the management of harbours on behalf of the Dominion government, he recommended "unified central management of the larger and more important harbours." Following his advice, the government in 1936 placed control of seven of the country's largest harbours under the control of a National Harbours Board. It seems likely that this new agency was created largely in the interests of cost efficiency, particularly given the Depression context. Corry goes so far as to suggest that part of the problem from the federal perspective was that competition between neighbouring harbours led to increased operating and maintenance costs, which had to be borne by the Department of the Marine. Thus, while the centralized harbour authority served to reduce the public expense involved in managing harbours, it was probably less responsive to local needs and concerns -- particularly as regards

competition from American ports -- than the previous system had been.[21]

As already suggested, the new Department of Railways and Canals took over the administration of these transportation links from Public Works in 1879. Little need be said about this agency, except that it was to be responsible for the "control and management of all government railways and canals, and of all works and property appertaining thereto."[22] In 1935, in view of the increased importance of road and air transportation, the department's responsibilities were expanded into these areas, and the name was changed to the Department of Transport.

Finally, it is useful to discuss the role of the Department of the Interior, insofar as its affairs had an impact on Canada's water resource. The Department was constituted by an Act of Parliament passed May 3, 1873, and was charged with administering the affairs of the Northwest Territories, Indian affairs, certain Dominion lands not under the jurisdiction of other departments, and with the ongoing Geological Survey of Canada. In the early years, most of the department's business was with the Indians of the Northwest Territories -- which at this time included Saskatchewan and Alberta. Between 1893 and 1896, however, the department's Irrigation branch made its presence felt; in 1894, for example, matters related to irrigation in the Northwest took up 150 pages of the department's Annual Report.[23] This of course, was because of the discussion and

debate surrounding the passage of the Northwest Irrigation Act in that year. In the previous year, the Irrigation branch had also been prominent. According to one historian of the department,

> In 1893 there was considerable discussion about reclaiming certain arid portions of the Northwest Territories by construction of a system of irrigation canals. The Northwest Irrigation Act was passed in 1894, and thus we have the origin of what is now [1963] the Water Resources Branch [of the Department of Northern Affairs and National Resources].[24]

The irrigation sector of the Department of the Interior was not always a distinct branch. Prior to 1912, it had been affiliated with the department's forestry service; after a brief interlude as a separate branch, Irrigation was absorbed by a new "Reclamation Service" in 1918. In 1912, another water-related function was assumed by the department when a Water Power branch was created.

Throughout its history, the Department of the Interior was important to the development of Western Canada, not least because of its role in irrigation and other water-related serveces. This importance continued after 1936, when Interior -- along with Mines, Indian Affairs, and Immigration -- was absorbed by the new Department of Mines and Resources.

As a postscript, a brief sketch of the history of federally administered hydrographic surveys can be given. Prior to 1904, such surveys had been conducted by a number of departments to serve particular needs. Most important in this respect were Public Works and Railways and Canals.

After 1904, this branch of the public service was assigned to the Department of Marine and Fisheries, "so as to systematize and facilitate the work in connection with the hydrographic surveys."[25] In 1936, responsibility for these surveys was assumed by the new Department of Mines and Resources.

Notes to Section 7

1. J.E. Hodgetts, Pioneer Public Service: An Administrative History of the United Canadas, 1841-1867 (Toronto: University of Toronto Press, 1955) p. 172.

2. J.H. Corry, Op. Cit., p. 146.

3. Ibid., p. 147.

4. M.V. Higgins, Canadian Government Publications: A Manual for Librarians, 1867-1931, p. 457.

5. Ibid., p. 456.

6. Corry, Op. Cit., p. 147. My emphasis.

7. Adam Shortt ed., Canada and its Provinces (1914) vol. 9, p. 251. My emphasis.

8. M.V. Higgins, Op. Cit., p. 8.

9. B. Hallett, comp., Records of the Department of Public Works (Ottawa: Public Archives of Canada, 1977) p. 1.

10. Ibid., p. 2.

11. Sir Joseph Pope, The Federal Government (Toronto: Glasgow, Brook & Company, 1914) p. 325.

12. The other four were Railways & Canals, Militia, Marine & Fisheries, and Naval Service.

13. Pope, Op. Cit., pp. 325-6.

14. Robert F. Leggett, Canals of Canada (Vancouver: Douglas, David & Charles Ltd., 1976) p. 103.

15. Ibid., pp. 105-6.

16. Ibid., p. 122.

17. Captain E.J. Chambers, The Canadian Marine: A History of the Department of Marine and Fisheries (Ottawa, 1905) p. 33. A Trinity house was a sort of fraternity or guild of masters and seamen who were responsible for lighthouses, buoys etc. prior to the assumption of these functions by the state.

18. Pope, Op. Cit., p. 377.

19. Chambers, _Op. Cit._, p. 33.

20. Corry, _Op. Cit._, p. 126.

21. _Ibid._, pp. 126-7.

22. Pope, _Op. Cit._, p. 327.

23. R.T. Flanagan, "A History of the Department of Northern Affairs and National Resources . . ." (Ottawa: Department of Northern Affairs and National Resources, 1963) p. 19.

24. _Ibid._, p. 19.

25. Chambers, _Op. Cit._, p. 58.

Conclusion

Any attempt to write the history of water in Canada must of necessity be partial and incomplete, unless the author aspires to be an encyclopedist. Even to simply enumerate the various uses of water as they evolved through time is an enormous task. Modern experts are able to define water as natural resource, chemical compound, and economic good, and to subdivide its uses according to an elaborate analytical grid. Each definition, each use of water that can be thus isolated has its own distinct history -- in most cases a history waiting to be written. For this reason, some very general conclusions are all that can be hoped for.

In general, it is clear enough that water has always been vital to human survival. Native societies have always relied on the streams that crossed their land as sources of food and drink and as a medium of transport. Early settlers added the provision of a motive force for grinding, sawing and other mechanical functions to this list of uses. In the nineteenth century, while western traders continued to use Canada's rivers to seek out new sources of fur, eastern industrialists expanded their productive capacity by applying water-power to various stages of the manufacturing process.

Traders and manufacturers, however, should perhaps not be mentioned in the same breath as Natives and settlers. Certainly the westward drive for new sources of beaver-fur

(and the concomitant exploitation of the material needs of Native peoples) and the mechanization of the manufacturing process (implying the destruction of the artisanal mode of production) are phenomena which are only very remotely related to the exigencies of human survival. In both cases, water intervened as a technical support to ventures in which economic profits were the real concern.

Perhaps the distinction between water-use for survival, and water-use for profit is one which should figure prominently in future water policies. Certainly Native societies have good reason to protest against the multiple threats to their way of life posed by huge dams built to provide cheap power for the North American consumer society, by industrial effluents which contaminate their food supply, and by a whole range of environmental problems caused by technologies whose main purpose is to increase the standard of living of the majority. Care should be taken to balance the economic benefits of increased and more complex water use against the objective needs of Native peoples.

Even more generally, the urge to make a profit from a resource such as water should be balanced against the need to preserve it for future generations. Canada is a water-rich nation, but poor management of resources can strain the circumstances of even the wealthiest society. Canadian federal water policy should be designed, above all, to address these concerns.

APPENDIX I

Terms of Reference

Objective

To provide a broad narritive or essay on the history of water uses and developments in Canada, with special reference to the role of the federal government in those developments.

Tasks

1. Review the history of water uses from pre-European to modern times, giving balanced treatment to different uses (navigation, fisheries, energy, industrial, agricultural, domestic, recreational) and to different regions of the country.

2. Describe the role of governments in major undertakings (e.g. Rideau, St. Lawrence canals, irrigation surveys, treaty negotiations), especially the policies of the federal government in supporting water-related developments and co-operative programs.

Inquiry on Federal Water Policy

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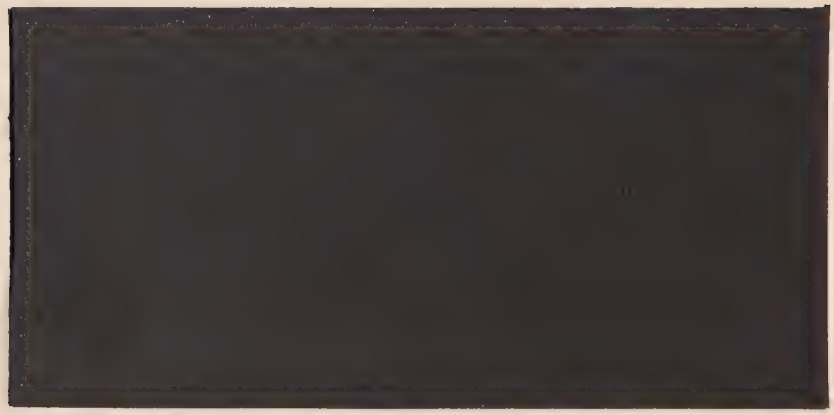

Inquiry on Federal Water Policy
Research Paper # 12

NORTHERN WATER ISSUES

by

Harriet Rueggeberg

Westwater Research Centre
University of British Columbia

March 1985
Vancouver

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn

Frank Quinn
Director of Research

Abstract

This study reviews the main water use and management issues in the Yukon and Northwest Territories and proposes measures to improve federal water administration in this part of the country.

The themes addressed are: the legal and administrative context in the North; northern water uses; water planning and management; the possible impact of aboriginal rights on water management; the jurisdictional and interjurisdictional issues; and finally, the water diversion and export issue as viewed from the North.

Résumé

Cette étude passe en revue les principales questions reliées à l'utilisation et à la gestion de l'eau dans les territoires du Yukon et du Nord-Ouest et propose des mesures afin d'améliorer l'administration fédérale des ressources en eau dans cette partie du pays.

Les thèmes abordés sont: le contexte légal et administratif dans le Nord; les utilisations nordiques de l'eau, la planification et la gestion des eaux; l'impact potentiel des droits aborigènes sur la gestion des eaux; les questions juridictionelles et interjuridictionnelles; et finallement, la question de la dérivation et de l'exportation d'eau vue du Nord.

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DISCLAIMER

Parts of this study are based on studies jointly undertaken by the author and A.R. Thompson of the Westwater Research Centre, and in that sense he shares responsibility for some of the recommendations. Otherwise, the recommendations are entirely those of the author, as requested by the Inquiry on Federal Water Policy.

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I. INTRODUCTION

This study deals with the vast area of Canada north of the 60th parallel--Yukon and the Northwest Territories. Its purpose is to provide an overview of northern water use and management issues for the Inquiry on Federal Water Policy. In particular, the objectives are:

1. to describe the characteristics of northern water resources and uses which make their management different from the management of resources in the southern regions of Canada;

2. to review the legal and administrative arrangements for water management and assess their effectiveness within the context of changing economic, jurisdictional and social conditions;

3. to recommend appropriate measures for improving the effectiveness of federal water administration, including the implementation of a policy and planning framework for water and land use.

To achieve these objectives, the study takes the following format. The remainder of this chapter introduces the reader to the basic administrative and legal arrangements that govern land,

resources and water in the North. Chapter II deals more directly with major water uses and issues related to their administration. The federal role in northern water management is identified and analyzed in the subsequent chapters, particularly chapters III and IV. The final chapter sums up the recommendations made throughout the report in a way that, it is hoped, points out the direction for improving federal legislation and administration in northern water management.

The information, conclusions and recommendations brought to bear on these issues were derived from several sources. The written and verbal submissions presented to the Inquiry during its hearings in Whitehorse and Yellowknife provided valuable insights into how northern residents, organizations, industries and governments view northern water issues. The author has drawn extensively on previous northern water and resource management studies carried out by Westwater staff for the Yukon River Basin Study (Fox, 1984a, b; Thompson and Ourum, 1984; Thompson and Rueggeberg, 1984); the NWT Water Board (Rueggeberg and Thompson, 1984d), the NWT Territorial Government (Thompson, 1984), the Western Constitutional Forum of the NWT (Rueggeberg and Thompson, 1984) and as independent efforts (Fox, et al., 1983; Rueggeberg, 1985). Through the course of many of these studies, the author has had the opportunity to discuss northern water matters directly with the people involved in its management in Yukon and the NWT in an effort to gain first-hand knowledge of how the management systems operate.

1.1 Northern Government

Yukon and the Northwest Territories (NWT) are called "territories" (as opposed to provinces) because almost all land, water and resources are still "vested in the federal Crown"; that is, they are owned and managed by the federal government and the federal Parliament has full legislative control over them. This differs from southern Canada, where all land, water and resources are vested in the provincial Crowns. The original confederating provinces kept these resources when Canada was formed in 1867, and as new provinces were created, they, too, were given resource ownership and management (though in the case of the western provinces, the transfer of resources was delayed until 1930).

The federal Department of Indian and Northern Affairs (DINA) acts as the primary administrator and coordinator of federal activities and decision-making in the North. Although based in Ottawa, DINA and several other federal departments which deal with northern matters have main offices in Whitehorse and Yellowknife, the capitals of Yukon and the NWT respectively, as well as local offices in communities throughout the territories.

Each territory also has a territorial government. These governments have evolved from being merely advisory agencies appointed by federal officials to responsible bodies similar in structure to current provincial governments. They have elected legislative assemblies and elected (NWT) or territorially appointed

(Yukon) Executive Councils (analogous to provincial cabinets) led by a Government Leader (NWT) or Premier (Yukon). (One difference between the two territories is that Yukon adheres to party politics like the rest of Canada, whereas political parties have no representational role in the NWT).

These territorial governments were "created" under federal statutes--the Yukon Act and Northwest Territories Act. These Acts list 22 areas of governance which the federal Parliament has delegated to the territories. These delegated powers parallel many of the powers granted to the provinces under the Constitution. However, several important factors limit the authority of the territorial governments. First, except for wildlife management and lands around towns and communities, the federal government retains control of land and resources in the territories. Second, under the Yukon and NWT Act, any legislation passed by the territorial governments is subject to all federal legislation, and is subject to scrutiny--and can be overridden--by the federal government before becoming law. Third, the territorial governments are "creatures" of federal legislation, and, although political considerations by now dictate against it, they could be dismantled by another Act of Parliament. This differs from the provincial governments, whose positions are recognized and therefore safeguarded under the Consitution. These facts emphasize the subordinate position of the territorial governments relative to the federal government.

This situation is changing. For many years, northern residents have been calling for government that is elected in the north, that is directly responsible to their needs and that has control over northern land and resources such that their needs can then be acted upon--the situation that exists today in the provinces. "Devolution" of federal authority to the territories has slowly become accepted federally as well as territorially and now, both levels of government are seeking ways of achieving this goal in an orderly, acceptable fashion. But the means being sought, the processes being proposed and eventually the final outcome may be quite different in Yukon and the NWT.

1.2 Administration of Northern Water Uses

As with most natural resources north of 60°, ownership of water is vested in the federal Crown, as stated in section 3(1) of Northern Inland Waters Act:

> "...the property and the right to the use and flow of all waters are for all purposes vested in Her Majesty in Right of Canada."

The Northern Inland Waters Act (NIWA), promulgated in 1970, is the statute by which the federal government manages northern water resources. In addition, s. 10 of the Territorial Lands Act provides that the bed, below ordinary high water mark, of any body of water in the territories is deemed to be reserved to the federal Crown unless expressly granted. As well, s. 9 reserves to the federal Crown a strip of land 100 feet wide along all coastal

waters and along the banks of all navigable lakes, rivers and streams (water is navigable, for example, if a canoe can pass along it).

The authority to administer these water resources of the Crown resides with DINA. Two administrative entities within the Department discharge this responsibility:

- the Water Resources Division carries out various policy, administrative, technical and enforcement functions in water management.

- the Water Boards, established under NIWA, provide for "the conservation, development and utilization" of the northern water resources. The Boards operate mainly as licensing authorities with respect to water use and waste disposal into water.

Other government agencies have a role in northern water management. Environment Canada's Inland Waters Directorate carries out research and provides information to the Water Resources Division and the Water Boards on natural characteristics of water systems and scientific criteria for developing water quality guidelines and standards. Also, the department's Environmental Protection Service acts as an environmental watchdog, providing information and advice concerning water pollution, and monitoring impact prevention and emergency response procedures. As well, it has a role in the prosecution of offences. To ensure public health

and safety, particularly with respect to drinking water and to health hazards related to improper disposal of sewage and waste in settlements and industrial developments, the federal Department of Health and Welfare maintains surveillance and ensures compliance with safe standards and practices. Finally, the territorial governments are responsible for providing municipal water and sewer systems.

1.3 A word of warning

Although the term "the North" is often used in an all-encompassing sense, this vast land is by no means uniform. There are striking differences in the environment, history, culture, and economic and political characteristics of Yukon and the Northwest Territories. As a result of these differences, governing institutions in Yukon and the NWT, even though they may have identical names, mandates and structures, have very different "chemistries". They operate under different priorities with respect to the resources they manage; they have different relationships among themselves and with the public; they have different approaches for dealing with the problems with which they are faced. This characteristic holds true whether one speaks of federal agencies, such as the Water Boards, or territorial bodies, such as the territorial governments themselves.

Consequently, the water issues described in the following chapters differ in their relevance to each territory or to regions

therein. For example, placer mining as a major water use is almost solely a Yukon concern, whereas the effects of dividing the NWT is obviously a NWT priority. Both territories are concerned about changes to water legislation and administrative regimes, but with different perspectives and with different sets of priorities as to what changes should occur first and how they should be implemented. Likewise, devolution of federal jursidiction over land, water and resources to the territories is a primary concern of each territory, but the approaches being adopted are also vastly different. An attempt has been made to point out these differences where applicable, but regional perspectives may often be missing because the author cannot represent a truly northern viewpoint from a Vancouver office.

The upshot is that analysts, advisors and administrators must be cautious when suggesting or applying blanket policies or processes to "the North"; what may be applicable in one region may be entirely inappropriate for another. Similarly, the casual reader should be aware that variety, not uniformity, is the norm in "the North".

II. NORTHERN WATER USES

2.1 General Features

The majority of northern waters are in virtually pristine condition. Given the North's sparse population, one might think that there is a super-abundance of readily useable water. Several factors, however, dictate otherwise.

- Much of the North's groundwater is in a frozen state year-round as permafrost, making it unavailable for direct use.

- Low temperatures in the North slow down many of the natural biological processes which help to break down pollutants. As a result, it is generally believed that northern waters typically have lower assimilative capacities than southern systems, and therefore, are more susceptible to pollution. In many cases this factor reduces the waters useability for municipal or industrial-use situations.

- In central and eastern NWT, where the Canadian Shield is the dominant geological formation, the water typically has a low buffering capacity against acids. Many other regions are characterized by already high natural levels of toxic minerals to which the natural systems in that region have adapted.

These high levels, however, may lower the water's useability for domestic and/or industrial waste disposal purposes because acceptable ambient levels are quickly exceeded.

° High sediment loading is typical of the water flowing out of the mountain ranges in western NWT and eastern Yukon, often making these waters of little use for direct consumption.

° The high arctic regions receive very little precipitation and are virtual deserts where year round supplies of water for even domestic use can be a problem.

As in the rest of Canada, water uses in the North can be divided into two general categories: nonconsumptive or instream uses--those uses that depend on the natural quantity and quality characteristics of a water resource; and consumptive uses--those that involve changing natural water flow or quality in some way.

For several reasons, attitudes in the North reflect a strong concern with maintaining the natural condition of northern water resources. Northerners are in the enviable position of being able to learn from the "mistakes" made elsewhere. Consequently a priority is not to protect what is <u>left</u> (as in much of southern Canada) but to maintain the pristine condition that is still the dominant characteristic of northern water resources, by avoiding these same mistakes. In addition, certain features of northern life depend on natural water conditions. The existence of small,

highly dispersed communities and the prevalence of traditional ways of life mean that direct domestic use of rivers, lakes and streams is widespread. The traditional way of life--of living off the land--is vital not just to the economy but also to the culture and integrity of aboriginal society. Native peoples place great spiritual and religious importance on being able to fish, trap and hunt for their livehihood, as well as on the sense of being in close commune with the land and its resources. This way of life depends on natural water conditions for direct use, for maintaining aquatic habitat for wildlife, for river transport, and for preserving the essence of true wilderness that is associated with northern rivers and streams.

Several commercial water uses also depend on natural conditions. These include commercial fishing, water-based activities associated with tourism and recreation, and commercial water transportation.

Consumptive water uses on the other hand are increasing in the North, as more resources of economic importance are discovered and the northern population grows. The greatest concerns, in terms of the impact on water resources, are focussed on uses that generate wastes into water. Industrial processing, particularly the production of mining wastes, and municipal waste disposal are two such areas of concern. Other consumptive uses--or at least ones that involve changing the natural regime--that occur to a limited

extent or are being contemplated are hydroelectric generation and diversion and export of water to areas south of 60°.

Water management in the North, as elsewhere, involves balancing the goal of maintaining natural conditions for instream use and the interests in developing non-renewable resources and economic activities. This potential conflict underlies many northern water use issues. The following issues are ones that have received particular attention in the northern water use scene.

2.2 Protecting Natural Water Conditions and Instream Uses

2.2.1 Information deficiencies

In order to know how man's activities are affecting the water environment and its capacity to absorb these effects before its "natural" state is harmed, it is necessary to have some understanding of the characteristics of that environment. Collecting sufficient information for a thorough understanding is a common problem everywhere, but is particularly acute in the North. Acquiring the necessary data is hampered by the vast distances, remote conditions and severe climate that characterize most of the North. Added to this spatial problem are the rapid changes over time that characterize many northern hydrologic regimes - fluctuations in flow rate, sediment loads, nutrient content, etc. that can occur over very short time periods with the sudden changes in seasons. In addition, the North is by no means uniform in

climate, topography, geology, and hydrology, so that what may be considered to be "standard" water quality for one region is irrelevant for another.

Efforts are underway to systematically gather information on northern water resources. The Inland Waters Directorate of Environment Canada collects water quality and flow rate data from a series of stations located in the major physiographic regions of the North. The Water Resources Division of the federal Department of Indian and Northern Affairs (DINA) monitors water conditions associated with mines and other industrial operations to ensure that they are complying with the terms and conditions of their respective water use licences. The federal Environmental Protection Service also monitors water conditions on an ad hoc basis wherever problems appear to exist. In general, however, these monitoring and data collection programs are widely dispersed over time and space, and do not provide sufficient information to define the natural condition and to assess man's effect on it with any degree of confidence.

Furthermore, there is also a general lack of scientific and technological information regarding water quality standards and pollution control measures for northern conditions. Most standards must be derived by extrapolating from information generated for southern climes. Similarly, much of the available pollution control and waste disposal technology has been developed for

southern conditions and its application must be rigorously tested in the North before it can be used with confidence.

2.2.2 Ways of protecting traditional water uses

Concern over protecting natural flow regimes and the uses dependent on them -- hunting, fishing, travelling, recreation and tourism, as well as maintaining fish and wildlife -- has surfaced throughout North America. Most provinces now recognize the importance of maintaining flow rates sufficient, for example, to protect fish and wildlife habitat, in water management policies if not in legislation. As well, recognition of instream use is evident in some allocation systems. In the NWT, for example, the Water Board recently imposed conditions in the water use licence for Cadillac Mine requiring that it maintain a minimum flow rate in the stream from which it draws its water.

There is even some statutory recognition of the importance of maintaining instream conditions and uses. The Northern Inland Waters Regulations, for example, define a "use for conservation purposes" as a water use that can be licensed under the Northern Inland Waters Act (NIWA).

While recognition of instream uses is increasing, the fact remains that these uses have not been allotted the same legal status, and therefore protection under law, as consumptive or appropriative water uses. In the North, virtually all uses for

which water use applications have been made and licences granted are consumptive uses; water supply, waste disposal, and diversions for construction purposes are typical, and all entail some change to the natural state of water bodies. To date, no applications have been made, and hence no licences issued, for non-consumptive water uses such as maintaining the natural state of a water body for the purposes of protecting hunting, trapping and fishing resources, to maintain outfitting operations, to enhance the experience of park users, or to protect the habitat of indigenous wildlife for its inherent value. This is the case even though "conservation" is defined as a "use" in the NIWA Regulations. Non-consumptive uses are presumably the object of protection in setting terms and conditions in individual licences, but in that manner, conservation is always an after-thought and never the primary use under licensing consideration.

A second component of protecting instream uses and users is compensation for loss or impairment of these uses. There can obviously be technical difficulties in assessing compensation for the loss of many instream uses. For example, what is the value of an accessible source of food that cannot be bought in a store or for a ready means of transportation for which there is no ticket vendor? More significantly, what is the value to the way of life these uses represent?

There are also administrative problems regarding compensation. The NIWA does provide for compensation for impaired or lost water

use under certain circumstances, but, as will be discussed in Chapter III, vagueness as to implementation and the current lack of stated water use priorities render these provisions ineffective.

2.2.3 Conclusions and Recommendations

Information deficiencies: An understanding of northern water conditions can come only from greater efforts to survey the northern water environments in detail, to monitor and document natural variability and changes wrought by man, and to conduct experiments on the effects in northern climes of practices acceptable in the South. We understand that the Water Resources Division of DIAND and other government agencies (GNWT, DFO, DOE) have developed proposals for more comprehensive monitoring and survey programs, to try to fill this knowledge gap. The Inquiry should actively support these proposals through recommendations to the Minister, based on the necessity of this information for a comprehensive approach to water allocation and northern resource management.

Protecting traditional uses: There are several ways in which instream and traditional water uses can gain a higher profile in northern water allocation and management. Most are measures that can be taken by the Water Boards or involve changes to NIWA or its Regulations.

- Through licence terms and conditions, the Boards can require that minimum stream flows be maintained. Provisions similar to the conditions in the Cadillac Mine licence in the NWT should become standard practice.

- The Boards should consider licensing instream water uses under the "use for conservation purposes" class in the NIWA Regulations. For instance, a government agency like the Department of Renewable Resources of the territorial governments, the Canadian Wildlife Service of the federal Department of Environment, or the Department of Fisheries and Oceans, could apply for a licence to "appropriate" water for the purpose of maintaining minimum flows for environmental or habitat preservation. Also, Hunters and Trappers Associations could apply for water licences to protect areas that are specially important for traditional instream uses.

- Under section 17 of NIWA, the Governor-in-Council may reserve lands from disposition for the protection of any water resource or in connection with any undertaking considered to be in the public interest. Furthermore, the Governor-in-Council may direct the Board not to issue any licences in a given water body so that comprehensive planning may proceed or where the waters are required for a given development in the public interest. Such a "development" could be a specified traditional use. Moreover, the Board has power under section 14 to make recommendations regarding any of the above matters.

Therefore, the Board could recommend the reservation of a particular stream for the purpose of an instream use that is in the public interest.

- A "use for traditional-use purposes" should be added to the classification of water uses set forth in s. 5 of the NIWA Regulations. Then, this use would receive statutory recognition, could be licenced as such, and would be a water use category that would officially be considered in any priority-setting endeavours.

- Finally, if changes to NIWA itself are contemplated, the Act should give explicit recognition to the prior appropriation of water rights evidenced by long-standing traditional uses by requiring the Boards to protect them through terms and conditions included in water licences, and by specifying clearly-defined compensation measures in the event these traditional uses are adversely affected by licensed uses (see chapter III for more comments on legislative changes).

2.3 Placer Mining

2.3.1 Information problems

Placer mining is primarily a Yukon activity, and its contribution to Yukon's economy is of great importance. For

example, in 1980, royalty was paid on 58,420 fine ounces of gold, the value of that gold at that time being approximately $44 million (Fox _et al._, 1983). In 1981, the industry provided about 235 man-years of direct and 118 man-years of indirect employment (_ibid._).

The major issue regarding placer mining stems from the effect of the mining process on waterways, and particularly its potential impact on Yukon fisheries. Placer mining can significantly reduce fish habitat in streambed locations where mining occurs. Modern mechanized operations dig, sort and re-distribute massive amount of gravels and sediments from river beds and banks, destroying what could be important fish spawning and feeding areas. Downstream of these operations, increased sediment loads -- created by discharging water used to wash or "sluice" the gold from the gravels -- may detrimentally affect fish and other aquatic life, although the use of filtration systems and settling ponds may mitigate these effects.

The placer mining industry contributes substantially to the Yukon's economy, both in generating revenue and providing employment, but it does so at a cost to the natural environment and resources uses -- fisheries, hunting and trapping, and outdoor recreation -- that are associated with it. Obviously tradeoffs between the benefits of mining and the benefits associated with the natural environment must be made.

But finding these trade-offs is laden with uncertainties. Data is limited in estimating the real value of placer mining in terms of its economic benefits to the territory as a whole and on a site-specific basis. Even less information is available for estimating economic benefits arising from fisheries, hunting and trapping or recreational use that could be used to compare with the economic benefits derived from placer mining on a site-by-site basis. Who benefits from each activity - Yukoners or foreign interests - is a controversial question. Moreover, making cost-benefit comparisons like this is always doubtful due to the many other intangible benefits that can be derived from either use of the resources; benefits associated with traditional, scientific, spiritual or intrinsic values. Finally, resource managers are uncertain as to the nature and extent of impacts caused by placer mining. This is due to insufficient information about such things as the distribution, activities and relative importance of fish stocks, and little understanding of just how much the natural environment can be perturbed before fish populations are seriously affected.

There appears to be general agreement that there should be some regulation of placer mining in order to minimize its impacts. But dispute arises over the degree to which impacts must be mitigated or compensated at the industry's cost, particularly given the relative economic significance of placer mining versus the fishery in the currently depressed state of Yukon's economy.

As Queenstake Resources Limited stated in its submission to the Inquiry:

> Placer mining in the Yukon is one of those very scarce endeavours in Canada where an individual, with minimal capital and hard work, can be self sufficient. It is the frontier spirit that deserves every effort by the rest of Canada to be preserved and allowed to grow. Apart from the cyclical gold price, the greatest threat to this lifestyle is the implementation by government of unrealistic placer mining guidelines. The economics of the industry are very fragile and the imposition of costly environmental water quality standards, that have little or no benefit, will irreparably damage this industry. Every effort must be made to encourage the placer mining industry so that it continues to maintain its important position in the Yukon economy.

2.3.2 Institutional problems

The institutional framework does little to relieve the tensions between conflicting interests, or to provide a means of arriving at satisfactory trade-offs. The Yukon Placer Mining Act is thought by many to be archaic in a society that is now aware of the importance of the environment and of regulating man's use of it. The Act is primarily concerned wtih defining the rights and administrative obligations of miners, and as Fox et al. (1983) point out, contains no provisions for environmental protection, for coordinating with other resources uses, or for allowing the benefits of placer mining to be reviewed in light of the benefits of other resource uses. The Fisheries Act is a powerful instrument for protecting fish habitat, and in so doing indirectly acts to protect the natural environment. It is aimed solely at fish and fish habitat and usually allows regulatory action only after a

harmful activity has begun rather than before. As such, it too does not provide the integrating and planning mechanisms needed for comprehensively managing resource uses.

The Yukon Placer Mining and Fisheries Act also do little to relieve the confrontational attitudes of the interests involved. The very nature of the Yukon Placer Mining Act perpetuates the free miner tradition of the industry, contributing to the industry's long-standing opposition to any restriction of its activities. In contrast, a literal interpretation of the Fisheries Act would totally prohibit placer mining activities wherever fish are present. Section 31 of the Act broadly prohibits "any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat," and section 33(2) equally broadly prohibits "the deposit of a deleterious substance of any type in water frequentd by fish." Furthermore, the Act fails to provide for, and therefore tolerate, other resource uses. As the Commission on Pacific Fisheries Policy (Pearse, 1982: 28) notes:

> The Fisheries Act remains silent on the existence of other resource uses or users, and this places the (Fisheries) officers in a very difficult position. The current referral process is working in spite of, not because of, the tunnel-visioned Fisheries Act. These officers do a very commendable job, considering their legislated terms of reference.

Placer mining uses water and disposes of "waste" in water ("waste" is defined in NIWA S. 2(i) (j) as "any substance that...would degrade or alter...the quality of those waters to an

extent that is detrimental to their use by man or by any animal, fish or plant that is useful to man..."); therefore, it comes under the purview of NIWA. Consequently, the Yukon Water Board has by default become the major regulator of placer mining in the territory. Although water licence terms and conditions must not vary from the standards of the Fisheries Act and its Regulations, protecting fish habitat to the extent called for under the Fisheries Act is not within the mandate of the Water Board or of NIWA. Therefore, a water licence issued under NIWA is not a guarantee to the placer miner that he is exempt from prosecution under the Fisheries Act, even if he complies fully with the terms of his licence. As a result miners complain bitterly of the regulatory uncertainties to which they are subject.

Finally, present implementation of NIWA deals only with allocating available quantities of water on a case-by-case basis. The Act has not been effectively used to review and plan the pattern of water uses appropriate to the interests of all Yukoners, including placer miners.

2.3.3. Conclusions and recommendations

The Yukon Placer Mining Guidelines Review Committee was established in March 1983 to hold public hearings to review proposed draft guidelines for placer mining operation and regulation. The draft guidelines were prepared by an interdepartmental committee composed of senior officials from DINA,

DOE and DFO. The report of the Review Committee was released in January 1984. The Committee aimed its recommendations at achieving three objectives: (Government of Canada, 1984:4)

> First, providing miners and public officials with legal certainty. Second, protecting existing investment. Third, the placer mining industry must be brought under a regulatory regime that is consistent with the nature and scope of environmental regulations that are applicable to other industries.

In terms of legal and policy issues, the Committee recomended:

> i) That as an interim measure, exemption should immediately be provided through regulations of the Fisheries Act and/or the Northern Inland Waters Act to allow placer miners to carry out established industry practices - most particularly, the returning of sluice water (deleterious substances/waste), at specified effluent standards to the water bodies from which they were obtained.
> ii) That in the longer term a thorough review of all legislation governing placer mining should be undertaken with the objective of making their application to the industry consistent, each with the other.

The committee also recommended that the Yukon Water Board should act as the single window for regulating placer mining through water licences, and that the necessary changes to the Fisheries Act and NIWA be made allowing the Board to take on these responsibilities. The Committee went on to make recommendations on the operational provisions of the draft guidelines.

The Minister of DINA apparently approves of the "general thrust" of the Committee's report, but to date, no direct action

has been taken from its recommendations. A government industry committee has since been formed "to look into various research and development projects for the purpose of implementing some of the recommendations and the guidelines" (Inquiry on Federal Water Policy Submissions, Whitehorse: 18).

Whether the review provided more indirect benefits - by allowing grievances to be aired and differing opinions to be put forward publicly - is difficult to tell. The placer miners clearly considered the draft guidelines to be too stringent to allow mining to continue as a viable industry, yet at least the review may have raised the general awareness of the "good" and "bad" sides of placer mining and the need to regulate it in a fair and open manner.

For now, the Water Board continues to be the primary regulator of placer mining activities. The Board's role has changed, however, since authorizations have been declared illegal and almost all placer mining activities must now be licensed. Chapter III describes this change in greater detail, but the long term net effect may be greater responsibility on mining licensees to account for the impacts of their operations.

2.4 Abandonment of Industrial Wastes

In the North, the most common form of industrial waste is that produced by mineral extraction and processing operations. These

processes often require the use of toxic chemicals; alternatively, the chemical processes can themselves produce noxious compounds, or can result in toxic substances being leached from the raw material itself. These compounds as well as solid materials end up in waste material. Treating and dispersing such wastes safely into aquatic systems is a problem everywhere, but it is particularly acute in the North. The colder temperatures slow down many of the natural or induced processes that can be used to degrade such waste material. The presence of permafrost has counteracting effects; for instance, water cannot penetrate into the ground very deeply, resulting in a myriad of shallow but interconnected lakes, ponds and streams. Waste discharged into one water body can therefore have a widespread effect through this interconnected system. In addition, in cases when discharge into a water system is deemed to be safe, it may be hampered by the extreme seasonal fluctuations in water flow rates.

Typically, liquid and semi-liquid wastes are discharged into and retained in tailings ponds, which may be held in man-made enclosures or naturally enclosed basins, where available. Some discharge from these ponds into local water systems may be allowed, depending on such factors as the toxic substances present, the effectiveness of the settling and degradation processes in the ponds, the water's chemical and biological characteristics, and the rate and volume of flow in the receiving environment. While the appropriate discharge and maintenance of these ponds is of concern, attention has also focussed on what to do with these ponds and

their contents, as well as solid industrial waste materials (dump sites, abandoned equipment, etc.) when operations end.

Regulating waste discharge into water comes under the purview of NIWA, but the Act is silent on the matter of abandonment. The Water Boards have nevertheless inserted conditions into water licences dealing with waste abandonment, but these conditions have been necessarily discretionary, usually implying that abandonment must occur "to the satisfaction" of the appropriate inspector or other authority. As yet there are no legislative or policy instruments indicating what is "satisfactory" abandonment. This situation leads to a number of questions:

- how could NIWA, its Regulations or other regulatory mechanisms provide for sufficient strictness to ensure that appropriate measures are taken in abandoning industrial wastes, but which are flexible enough to allow for changing technology and differing circumstances?

- how can the regulatory system ensure that those in charge are sufficiently expert to judge whether abandonment measures taken in any particular case are "satisfactory"?

- for how long should the operator or licensee be responsible for the abandoned wastes, given the uncertainty regarding long term or long range effects of those wastes?

- how can enforcement of abandonment measures be ensured for long term effects?

2.4.1 Conclusions and recommendations

Obviously, this issue needs further examination and research in a technological sense. From an administrative perspective, a policy or set of guidelines is desirable so as to waylay the present uncertainty regarding "satisfactory" abandonment procedures and the extent of responsibility of the industrial user. Some recognition in NIWA of the Boards' authority to deal with abandonment is also desirable. Finally, the Government of the NWT has expressed concerns in the past regarding abandonment procedures and their regulation. Under their mandate to protect municipal water supplies, the territorial governments might consider including regulatory provisions regarding abandonment in territorial legislation regarding environmental protection. If so, the respective territorial governments and Water Boards should coordinate their regulatory functions. Taking control of the regulation of waste abandonment could be a significant step in the transition of water resource management from federal to territorial authority.

2.5 Hydroelectric Power Development

A variety of studies have shown that there is considerable potential for hydroelectric development in the North. It has been

estimated that Yukon alone has a potential of 11,000 MW (assuming 60% capacity factor); currently, only 78 MW has been developed (Fox, et al., 1983). No territorial-wide survey has been done for the NWT, but regional studies have estimated a 1600 MW potential for the Keewatin District alone (Ruitenbeek, 1983).

Counteracting these favorable potential estimates are economic considerations. Costs for construction are significantly higher than south of 60°, given adverse northern climatic conditions and the distance from major suppliers of materials. Development would often not be cost effective as many of the potential sites are too far away from markets. (As an alternative to large scale proposals, the NWT Science Advisory Board has examined the feasibility of developing small-scale facilities (100-5000 KW) for use by individual communities (see: Ferguson, Simek, Clark Ltd., 1983)).

Regardless of the economic disadvantages, however, there are those who argue that the North is a vast storehouse of hydroelectric power, and that this potential should be protected. Proponents of this point of view argue further that it may be feasible to develop high potential sites on the prospect of luring industry to the north with the promise of cheap power. More lucrative might be development for export of electrical power.

These arguments meet opposition not only from those who argue on economic grounds, but also from an environmental standpoint.

Large scale development again impacts the fish, wildlife and wilderness resources, and affects those who depend on them.

2.5.1 Conclusions and recommendations

The most contentious issue regarding hydropower development in the North is whether developing power for export should be considered a viable and desirable strategy. This is really a political decision and the author refers the reader to the opinions expressed in the northern submissions to the Inquiry.

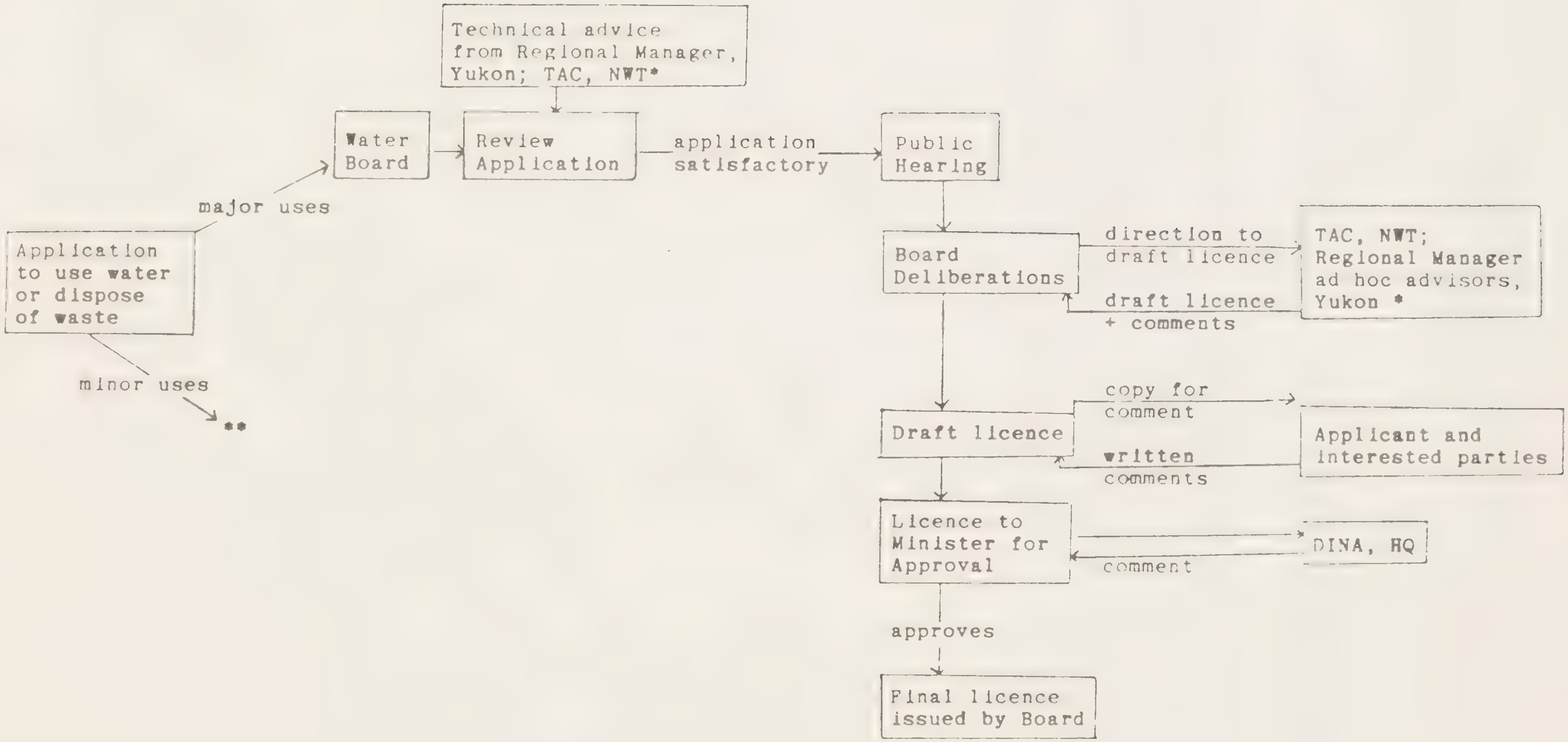
III. LEGISLATION AND ADMINISTRATION

3.1 The Licensing Process

The major tool by which water use is regulated in the North is the water licence, issued under the Northern Inland Waters Act and its Regulations, by the Water Board of each territory. The process for licensing water use in the territories is shown schematically in Figure 1.

The northern water management system is unique in Canada in that both water quality (waste discharge) and water quantity (allocation) are regulated under one statute and administered by one body. In contrast, the provinces typically deal with water allocation and water quality under separate licences and administrations, often leading to a lack of coordination and integration in these two important aspects of water management. The northern scheme largely eliminates this problem. Furthermore, as Figure 1 indicates, water licensing is very much a public process, whereby northern residents who may be affected by a given water use may become informed of its features and voice their concerns to the appropriate Board. Finally, water licences are always issued for a fixed term, anywhere from one to 25 years, and upon renewal they are publicly reviewed again and revised if necessary.

Figure 1. Water Boards' Licensing Process



* In the NWT, advice is sought from a permanent Technical Advisory Committee (TAC). In Yukon, advice is sought from the Regional Manager, Water Resources Division, DINA who consults with members of his department or of other departments.

** See text regarding how routine and minor water uses are now handled.

Despite these favorable characteristics, however, the water licensing system, the legislation and the general administrative framework still have their problems. Some of these problems are discussed in this and the next chapters.

3.2 Regulating Lesser Water Uses

Under s. 26(g) of NIWA, regulations may be made by the Governor in Council authorizing water use without a licence. Prior to 1984, authorizations were issued by a Controller of Water Rights (the Regional Manager of the Water Resources Division of DIAND) for water uses specified in s. 11 of the NIWA Regulations; municipal use by an unincorporated area, water engineering uses, or uses where the period did not exceed 270 days or the amount was not in excess of 50,000 gallons per day. This authorization process was an inexpensive and expeditious method of approving routine or minor water uses as compared with full licensing by the Board with its requirement of a public hearing. But its legality was challenged before the Federal Court of Canada in The Dene Nation v. The Queen (Feb. 14, 1984) where Madame Justice Reed held that s. 11 exceeded the statutory authority given in s. 26 (g) of NIWA to make regulations authorizing the use of water without a licence. Immediately following this decision, the Governor in Council passed a new s. 11 of the NIWA Regulations which simply repealed the former s. 11 and provided that water can be used without a licence for municipal purposes by an unincorporated settlement or a construction camp, for water engineering purposes or for a rate not

in excess of 50,000 gallons per day (SOR/84-157). This new s. 11 therefore dispenses with the authorization system and requires water users to judge for themselves whether a licence is required in the circumstances of their case. This leads to uncertainty concerning the need for a water licence. It also means that without the records formerly provided by the authorization system, the Water Boards and regulatory staffs will have difficulty in acquiring a complete view of all water use in their respective territories, compromising their ability to allocate and manage water resources in a comprehensive manner.

In the NWT, the Water Board tries to deal with this dilemma by requesting all water users to make applications which the Board then screens as to whether or not the proposed water use is in an exempt category. As well, both the Yukon and NWT Water Boards maintain that since almost all water uses release some form of waste into water, these uses must still be licensed under s.6 of NIWA regardless of whether or not they are exempt under s. 11 of the Regulations. Section 6 states:

> 6. (1) Except in accordance with the conditions of a licence or as authorized by the regulations, no person shall deposit or permit the deposit of waste of any type in any waters or in any place under any conditions where such waste or any other waste that results from the deposit of such waste may enter any waters.

In Yukon, almost all placer mining operations had fallen into the old authorization category; for example, 150 authorizations were issued for placer mining in 1982. Now, since placer mining

deposits wastes, all these operations have to be processed under the more rigorous and time consuming licensing process, which creates an immense workload for the Water Board.

To overcome this processing crisis, during the spring of 1984, the Board formulated "Draft Rules for Expedited Procedures" for licensing placer mining operations. These expedited procedures differ operationally from "regular" licensing procedures for other major water uses in several ways.

- The applicant is requested to fill out a detailed information sheet as well as a regular application form. Due to the basic similarities of mining operations, these sheets provide sufficient information to the Board and technical advisors to decide whether or not to accept the application for a public hearing. Obviously, it is to the applicant's advantage to fill out the sheet as completely and accurately as possible, to expedite the processing of his/her application.

- A public hearing is advertised for each acceptable application. For the majority of applications during 1984, no responses indicating intent to intervene were received by 10 days prior to the hearing date, and the hearing was waived with the applicant's consent (a consent form was attached to the information sheet which the applicant could choose to sign.) If a hearing was required, presentors were limited to

ten minutes. (The Board has not found it necessary to limit presentors under this rule.)

- Written comments rather than oral presentations were used extensively during 1984, especially by DFO whose comments were largely identical for all applicants. The applicant could choose to respond to these comments, and the comments were considered by the Board and technical advisors in setting the conditions of the licence.

As a result of these procedures, only three of 310 placer mining applications during 1984 required public hearings. While these procedures greatly reduce the time and effort normally expended on major water licences, there are several major differences between the new licences and the authorizations formerly issued to placer miners (these points were raised in a discussion with B. Lendrum, Water Board Secretary).

- Licences contain a monitoring schedule which requires the licencee to check water quality upstream, downstream and at the point of effluence. A simple settleable-solids test using an Imhoff cone is used, which the miner is expected to conduct weekly and report monthly. No such monitoring schedules were required under authorizations.

- An "objective" (though not a standard) for water quality in terms of ml. of settleable solids per liter of water is set in the licence. In authorizations, water quality was determined "to the satisfaction of the Controller".

- Construction standards are set in licences, in terms of the ability of structures to withstand certain maximum river flows. Not meeting these standards is a ground for licence cancellation.

- The information requirements for applications are much more extensive for licences than they were for authorizations. This is in part due to the greater demands of a public process, but also because the terms of the licence are tied directly to the details provided in the application. There is therefore a strong incentive to the miner to make the application as complete and accurate as possible.

- Similarly, whereas a miner operating under an authorization could simply call an inspector for approval if he wished to change his operation (in essence, amend his authorization), a licencee must formally apply for an amendment to his licence if he wishes to have legal endorsement of changes to his operation.

The draft Rules for Expedited Procedures for licencing placer mining were not formally approved before they were used for the 1984 season. They are now in the process of being approved by the federal Department of Justice and the Privy Council, before being gazetted under the Statutory Instruments Act.

3.2.1 Conclusions and recommendations:

There is considerable support for amendments to the Act that would introduce a process for issuing permits for relatively small, routine water uses that would be less rigorous than the current water licensing process and would not include any public hearing requirement. It is important that the new permits be given full status alongside licences in terms of standing and priorities. Therefore, their issuance must be fully integrated with the licensing process. For this reason, the new permitting process should be established under the jurisdiction of the Board; that is, whoever would be authorized to issue permits be responsible to the Board rather than to DINA. Both permits and licences should be entered in the Water Use Register as required by s. 19 of NIWA, and the Register should be maintained by Board staff.

The Yukon Water Board's draft Expedited Procedures for licencing placer mining could provide a useful model when considering what should be the components of a permitting system.

Currently, the Procedures take account of the public process inherent in water licensing; but in an operational sense, the ways which the technical procedures and interdepartmental referrals occur lend themselves well to adaptation to an in-house review and permitting process.

3.3 Water Quality Standards and Water Use Priorities

The NIWA authorizes the Governor in Council to make regulations prescribing water quality standards (s. 26c). It states that waste "will be treated and disposed of in a manner that is appropriate for the maintenance" of these water quality standards (s. 10(1)(b)), and that a Board may attach any conditions to a licence, "including conditions...based upon water quality standards prescribed (under the Act)" (s. 10(2)). Similarly, the Act authorizes the Governor in Council to make regulations classifying water uses and "providing for the priorities among the classes of use of waters..." (s. 26(d)).

Despite these provisions, standards and priorities have not been established under the Act. This is at least partially due to vagueness in the Act regarding the nature of these standards and priorities and how specifically they should be used. For instance, the Act is not clear whether "standards" are to be legally binding without any variations permitted, or merely to be guidelines or desirable objectives. With priorities, the Act defines the effect to be precedence of use (s. 22), but it obviously did not envision the difficulties associated with actually determining which use or

uses will have precedence over others. Yet, many important aspects of the water allocation system established under the Act -- such as compensation -- are virtually meaningless without a system of priorities in place. While other factors have played a part in the current lack of standards and priorities (see Chapter IV) the vagueness of the Act has not helped the situation.

3.3.1 Conclusions and recommendations:

The present uncertainty regarding the meaning of standards and priorities needs attention. Ways to establish standards and priorities within a water planning context are suggested in the next chapter. As for dealing with them in legislation, ideally they should be defined in NIWA so that they can reflect water management objectives that are developed in a planning framework and also allow administrative flexibility in using them--that is, they are not legally "written in stone". Such a definition could read as follows (Thompson and Rueggeberg, 1984; 88):

> "water quality standards" shall mean statements of desirable levels and concentrations of waste substances and methods of waste treatment that operate as guidelines to accomplish water management objectives as may from time to time be determined by the appropriate Water Board for water management areas.
>
> "Water use priorities" shall mean statements of water use preferences that operate as guidelines to accomplish water management objectives as may from time to time be determined by the appropriate Board for water management areas.

Such a definition could also be enacted as a regulation (under s. 26(q) of NIWA) rather than as an amendment to the Act itself, thereby involving a simpler legislative process.

This approach to defining standards and priorities in legislation has the advantage of giving statutory acknowledgement to guidelines for water quality standards and water use priorities established in a planning framework, but still retaining the decision-making flexibility associated with guidelines. At the same time, having guidelines set in regulations rather than merely as policy statements provides them with the added weight and credibility of legislative authority. The guidelines would then be translated into legally-binding terms and conditions by the licensing decisions of the Water Boards.

3.4 Compensation

A third problem regarding NIWA are obscurities and inconsistencies regarding compensation. The Act states that lower priority licensees who are adversely affected by a new licence of higher priority are entitled to compensation, but obviously this is meaningless when there is no priority scheme in place. Furthermore, means for measuring compensation are not stated, and the affected licensee must pursue any remedy in court, where he/she has the onerous task of proving "adverse effect".

More significantly, the Act does not provide for rights of compensation to non-licensed water users. The Act does authorize

the setting of security, but the relationship between security and compensation is not defined -- yet security is the only avenue by which non-licenced water users who may be adversely affected by a licensed use may be protected.

3.4.1 Conclusions and recommendations

If amendments to NIWA are contemplated, compensation measures should be clearly defined. Compensation where traditional (unlicensed) uses are adversely affected by licensed uses should be clearly recognized and appropriate measures and forms of compensation spelled out. Compensation should also be clearly provided where prior licencees are affected by subsequent licences who acquire a licence because their use is of higher priority, according to priority guidelines or decisions by the appropriate Board.

As for the measure and form of compensation, it is not realistic to assume that compensation will in fact result, especially in favour of unlicensed long-standing traditional users or small licencees, unless the questions of measure of damages, proof of loss and procedure for claims are addressed in the Act. To leave these matters to be resolved according to common law rules about the measure of damages and by ordinary actions in the courts is tantamount in many cases to a denial of compensation. While an arbitration procedure can simplify claims in many cases, yardsticks for measuring compensation for anticipated loss of water flows and volumes, as well as for anticipated loss of water quality, are

than specific assessments of loss in each individual case. This subject requires further study.

Amending NIWA may not be desirable at the moment. However, attaining compensation under the current NIWA, particularly for instream users, is very difficult -- because these uses are unlicenced and also because losses to these uses are difficult to measure and prove. Due to these limitations in NIWA, we caution that the Board would run into legal pitfalls trying to implement a compensation program under the current legislation for traditional and other unlicenced instream uses. The GNWT's Renewable Resources Compensation Policy has the potential to provide an avenue of redress to traditional water users in some circumstances. Its primary weaknesses at present are its status as a policy rather than as legislation of the NWT, and the fact that, as yet, it has not been really tested. The status could change if the GNWT exercises more of the legislative power bestowed on it by the Northwest Territories Act. We suggest that the Territorial legislatures should be encouraged to provide full legislative support for compensation programs which could impose on developers a general obligation to make good the losses which are imposed on the traditional users of natural resources.

3.5 Other Legislation

Issues associated with the Yukon Placer Mining Act and the Fisheries Act were discussed in chapter II. Although the Canada

Water Act has been in force for fifteen years, and has significant potential in the field of water management agreements and water quality control, it has been used in the Northern context only as the framework for river basin studies in the Mackenzie and Yukon rivers. The Arctic Waters Pollution Prevention Act and the Ocean Dumping Control Act apply to marine waters and regulate water use from waste disposal and transportation perspectives. These regulatory aspects are becoming increasingly important to the people of the Arctic coast, particularly as the rate of offshore drilling and tanker transport increases. But the Acts, unlike NIWA, do not provide for public input of any kind into the management of coastal waters, including such matters as waste disposal standards, timing and location of drilling and liability of operators (MacLachlan, 1984).

IV. PLANNING AND MANAGEMENT

4.1 Who Plans?

Water allocation under the licensing system described in the last chapter occurs on an ad hoc, reactive basis, with no official long term goal to guide allocation decisions. As the holder of province-like powers over natural resources in the North, DINA claims the authority for providing this policy direction but, so far, no clear policy has been put in place. There are those who believe that the Water Boards--because they are the primary allocating authorities, because they hold hearings and solicit public opinion, and because they are based in their respective territories--should have a role in water planning. There is some resistance to this notion, however, among federal officials who view the Board's role as merely to issue licences, and who feel that a planning role would not be in keeping with the quasi-judicial role of the Boards' licensing activities.

The previous chapter noted that water quality standards and water use priorities called for under NIWA, have not yet been established. Many critics argue that rational and accountable allocation, planning and management is impossible without them. Again, who is to be responsible for their development is not apparent. Both the NWT Water Board (see Rueggeberg and Thompson, 1984d) and DINA are conducting separate policy studies into what

and how standards and priorities should be set. The Inland Waters Directorate of Environment Canada is also conducting investigations into appropriate water quality standards. Recently, in the NWT, the Territorial Government initiated a study of policies for setting standards and priorities. One might hope that these studies will lead to better coordination of efforts and greater cooperation of the agencies involved, though at present the efforts seem fragmented and duplicative.

4.1.1 Conclusions and reocmmendations

There are those who argue that any planning-type activities are not part of the mandate of the Water Boards. Section 9 of NIWA states, however:

> 9. The objects of the boards are to provide for the conservation, development and utilization of the water resources of the Yukon Territory and the Northwest Territories in a manner that will provide the optimum benefit therefrom for all Canadians and for the residents of the Yukon Territory and the Northwest Territories in particular.

Allocating water use through licensing is the heart of the Board's mandate, but this licensing function must serve the purposes dictated by the wide-ranging requirements of s. 9. Furthermore, s. 14, which empowers the Board to make recommendations to the Minister, and s. 15, which authorizes the Board to hold public hearings concerning its objectives, provide the necessary powers to enable the Board to take a comprehensive, 'pro-active' approach

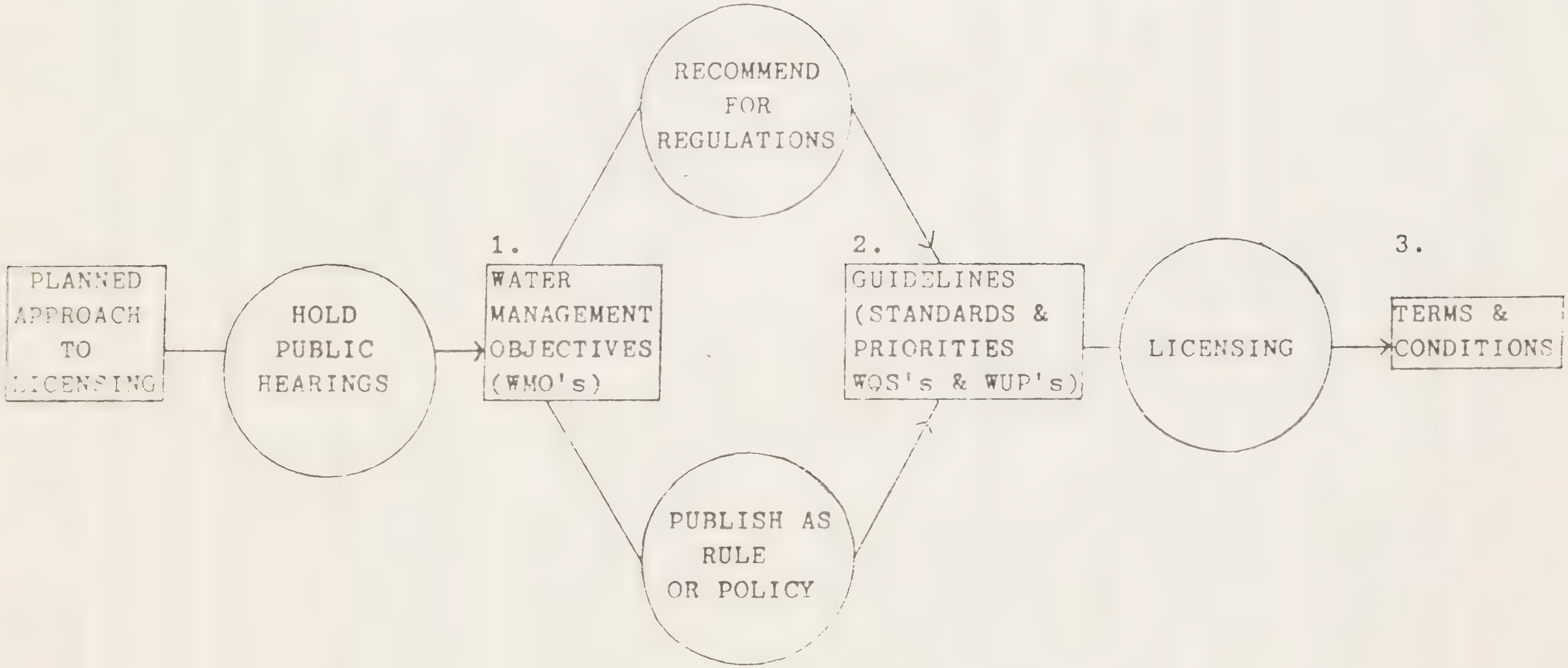
to licensing, rather than to merely judge each application individually in a purely reactive manner.

Such a planning-for-licensing approach does not undermine the quasi-judicial role of the Board in the licensing process because planning functions can be easily separated from regulatory proceedings. There is ample precedent for reconciling these functions. For example, the National Energy Board operates under quasi-judicial rules in reviewing applications for certificates of public convenience and necessity, yet it also carries out such planning-type functions as holding public hearings to estimate future energy supply and demand and to determine the preferred means of delivering energy to different regions of the country.

A previous study (Rueggeberg and Thompson, 1984d) proposed a planning-for-licensing approach in the context of setting standards and priorities that could be adopted by the Water Boards. This approach is shown diagramatically in Figure 2.

There are three main components in this appraoch. First, water management objectives (WMO's) are established by involving the public through a consultation process in the formulation of basic principles and goals that should underpin the licensing system. Second, based on these WMO's, detailed water quality standards and water use priorities are developed as guidelines by the respective Water Boards and either enacted in regulations made under NIWA or adopted and published by the Boards as rules or as

Figure 2. Model of planned approach to licensing.



from: Thompson and Rueggeberg, 1984: 81

policy statements. Third, the Boards use these guidelines in dealing with applications and in determining licence (and permit) terms and conditions.

(i) Developing WMO's: Each Water Board, in consultation with the appropriate territorial government, the regional Water Resources Division of DINA, and its other technical advisors, would develop draft water management objectives for its respective territory. (In the NWT, the Water Board has already drafted a set of decision-making principles for its licensing function. These could provide the basis for developing WMO's.) In general, WMO's would state what water uses are to be maintained, what are goals for water quality, and how these WMO's would be implemented. The draft WMO's would be reviewed in public hearings held by te Board under s.15 of NIWA, and the Board would issue a report adopting the WMO's following revisions made in light of the hearings.

The Boards could initially develop WMO's for their entire respective territory. However, deriving management objectives on an area-specific basis is advantageous, to allow local conditions and goals to guide water allocarion and protection. Therefore, it would be desirable for the Boards to gradually derive WMO's for individual areas, perhaps as areas become "hot spots" in terms of conflicting water use interests, using the general (territorial) WMO's for guidance. Developing such area-specific WMO's would also involve holding local public hearings. In time, particular water

management areas might have WMO's "tailor-made" to meet their particular features and demands. In this way, developing WMO's would be a dynamic process.

(2) Developing guidelines: At this step, each Board's staff, with the assistance of technical advisors and input from the territorial governments, would translate the adopted WMO's into detailed water quality and water use guidelines specifying such things as numerical values or range of values, treatment processes and minimum flow requirements. These guidelines could be circulated to the public in draft form before being released.

These are several ways in which such guidelines could be adopted. The Baords could formally adopt the Guidelines as policy statements or as Board rules, under the power given the Boards by s.18 of NIWA to make rules for carrying out its business.

If, however, water quality standards and water use priorities are redefined in NIWA or its Regulations in the way suggested in chapter III, then the Boards could submit the guidelines to the Minister of DINA with the request that they be promulgated as regulations under s.26(d) and 26(c) of NIWA. This approach would have the advantage of allotting statutory acknowledgement to the guidelines but at the same time, would retain the Board's discretion in applying them.

(3) Application in licence terms and conditions: The final step in this approach would see the implementation of the guidelines. They would act to guide the Boards in deciding whether to approve or reject licence applications and, if so, what terms and conditions to impose in them. It must be emphasized that the guidelines are not binding on the Board, but since they are public statements, they would put an onus on the Boards to give adequate reasons for deviating from the guidelines in any particular case.

4.2 Integration with Land Use Planning

In 1981, in response to the perceived need for a planning framework in the face of burgeoning resource development in the North, the federal Cabinet approved the development of a Northern Land Use Planning Policy. Initial attempts at a proposed policy were unsuccessful in gaining northern support. In the NWT, subsequent negotiations with the territorial government and, eventually, with major native organizations, led to an agreement on a set of planning principles and an administrative framework in July 1983. Both levels of government finally approved this agreement in November 1983. Implementation has been slow to get off the ground, however, as final approval and funding has had to await first Privy Council and then Treasury Board review.

In Yukon, however, while the territorial government initially signed a land use planning agreement with the federal government, DINA added a few last-minute provisions that conditioned federal

approval. The Yukon government could not agree with these appended provisions, the agreement fell through, and a stalemate currently exists. DINA and the Yukon government are instead independently pursuing land use plannng policies.

In looking at the planning framework being proposed in the federal-territorial agreements for the NWT, a break-through in northern land administration is evident in that the territorial government is given an equal position of authority with the federal government for the first time. Furthermore, the make-up of the administrative bodies (the Land-Use Planning Commission in particular) favors public representatives as opposed to members of federal or territorial bureaucracies.

In terms of its impact on water, a significant element of the proposed planning framework is that the concept of land use planning explicitly includes water. The agreement states that "the plans will provide for the conservation, development and utilization of land, resource, inland waters and the offshore". However, there is no indication in the agreement of how water will be dealt with in the planning process or in the administrative structure. Moreover, there are as yet no signs of how the current water licensing and water management systems will be coordinated with land use planning endeavors. Therefore, while the northern land use planning program may be regarded by some as the future solution to northern resource use problems, the apparent lethargy in its implementation even on an experimental basis, and the

absence of suggestions for how water will be integrated, still leave the issue of water planning in doubt.

4.2.1 Conclusions and Recommendations

Given the structure of the northern land use planning process that has been proposed for the NWT, several options regarding ways to integrate water planning and allocation come to mind:

- Each Water Board could proceed on its own to discharge its regulatory and allocative mandate, ceding all planning responsibilities to the land use planning process. In carrying out its regulatory functions, it would decide in each case the extent to which its decisions would adhere to "plans" established under the land use planning policy. This option would lead to little involvement in plan formulation, and as a result, little commitment on the part of the Boards to such plans. The indifference that might be created at the regulatory level could result in plans being largely ignored so far as water management is concerned.

- Alternatively, although its quasi-judicial status may preclude a Board from having members on the Policy Advisory Committee or Land Use Planning Commission, these groups could still systematically invite the appropriate Board to comment on water-related issues in the planning process. The Board could draw on the objectives, standards and priorities derived from

its own planning-for-licencing process when providing information to the land use planning process, particularly where regions of common interest overlap.

° The Land Planning Commission could also ask the territorial Water Board to hold public hearings regarding water management plans and priorities for any given planning region if it has not already done so. The water management and planning criteria so established could then be integrated in the respective land use plans to the extent possible. This would "lighten the load" of the Commission and its support staff and would also accomplish the much-needed coordination between land and water use planning and regulation. Even if the Commission did not request the Board to hold hearings, the Board could do so on its own initiative, using the results to formulate responses related to water issues for other land use planning forums.

° Planning regions could be identified on the basis of watersheds; for example, water management areas have already been established in each territory under NIWA, and could be used as a general guide, especially where major issues regarding water use have already arisen -- for example, the Fort Smith area surrounding the Slave River.

- The technical advisory staff of the Water Board and the Land Use Planning Commission could have common members, to encourage adherence to common goals and principles.

While the Water Boards may carry out planning for their water licensing functions, the responsibility for overall water resource policy will still rest with DINA and, in the future, with the territorial governments. The Water Boards and the northern land use planning processes will have to conform to this overall policy as it is developed. It is to be hoped that direction as to what this policy might be will be available by the time land use planning gets underway.

V. ABORIGINAL RIGHTS AND COMPREHENSIVE LAND CLAIMS

5.1 Impact on Water Management

The economic, cultural and religious importance of the North's water resources to its aboriginal peoples was emphasized in Chapter II. Ways by which aboriginal people can protect these important elements of their way of life are being sought on several fronts. Foremost are efforts to attain a definition and recognition of aboriginal rights in the Canadian Constitution. While the nature of these rights remain as yet ill-defined, it is unlikely that efforts to achieve such definition would neglect spelling out the rights of native people to the use and management of such a vital resource as water. Precedents are already being set in defining aboriginal water rights in the southwestern United States.

There is also an increasing claim among aboriginal people throughout Canada for forms of self-government. Efforts are also being focussed on having the concept of self-government enshrined constitutionally. A long-term goal of DINA is the devolution of local powers to Band councils, with Bands eventually taking on the appearance and powers of a municipality (R. Barnhart, DINA, pers. comm., 1985). While the exact implications for northern water management are not known, certainly substantial effects will be felt.

Aboriginal land claims can have considerable impact on the use

areas. Land claim settlements can define special rights regarding ownership, use and management powers for waters within claimed areas. Also, they may define how the aboriginal peoples involved will participate in resource management institutions affecting water resources, thereby impacting on management decisions regarding water use elsewhere. Finally, how aboriginal peoples use the waters to which they have defined rights or managerial powers can have effects on users beyond the claims area.

5.2 The Inuvialuit Final Agreement

The Inuvialuit Final Agreement involving the Western Arctic, signed in July 1984 by Canada and the Committee for Original Peoples' Entitlement, is the only comprehensive claim that has been settled in the North. Its provisions for water management are therefore significant as potential precedents for future claims, and indicate the possible effect aboriginal land claims can have on northern water management.

The Agreement establishes the boundaries of an Inuvialuit Settlement Region in which the Inuvialuit are granted title to 5,000 square miles of land in fee simple absolute, including all minerals and hydrocarbons, and 30,000 square miles in fee simple excepting minerals and hydrocarbons. Within this region, there will be certain laws (game management, environmental assessment),

certain rights (entitlement as an Inuvialuit) and certain institutions (for fisheries, game and wildlife management, research, environmental review) that will be unique and not necessarily shared in other parts of the NWT or Yukon.

In terms of water, sections 7(2) and 7(3) of the Agreement state that the Inuvialuit will own the beds of all lakes, rivers, and other water bodies in the Inuvialuit lands, but the Crown will retain ownership of all waters. This arrangement suggests that the Crown, through the Water Board, still has the authority to allocate water rights, but that any rights that require the use of or affect the beds of a water body cannot be exercised without the permission of the appropriate Inuvialuit authority. This is qualified in s 7(85) which states that Canada retains the right to regulate water bodies for the purpose of managing fish and migratory birds and their habitat, and for navigation, transportation, flood control and other governmental functions (in consultation with the Inuvialuit Land Administration).

In essence, Inuvialuit control over the water resources in their lands is by no means total, particularly where government functions (as opposed to control over private enterprise) are concerned. This may well be to the Inuvialuit advantage, though, as it leaves many costly but essential functions in the hands of the federal or territorial governments, while still allowing the Inuvialuit some voice in these matters through obligatory consultation and a virtual veto power if the beds of water bodies are involved.

5.3 Other Claims

Other comprehensive claims being currently negotiated in the North are those of the Dene Nation and Metis Association collectively (for the western Arctic south of the Inuvialuit lands), and the Tungavik Federation of Nunavut (for the eastern Arctic). Settlement negotiations with the Council of Yukon Indians are currently suspended (Minister's letter of December 20, 1984). Provisions regarding these claims are not made public while negotiations are still ongoing, so their effects on northern water resources are not known. Submissions to the Inquiry by these organizations may clarify their stances in this regard.

5.4 Conclusions and Recommendations

Little more can be said regarding aboriginal rights, self-government and land claims other than to emphasize that their definition and settlement will be major determining factors in the direction that resource management will take in the North. This is particularly true in the NWT, for nowhere else in Canada are native people in a demographic and political majority.

VI. JURISDICTIONAL AND INTERJURISDICTONAL ISSUES

The current state of almost total federal jurisdiction over resources in the North has received increasing criticism by northerners who feel that regional and territorial concerns and interests are being overridden by national ones, and that northern residents should be entitled to the same degree of representation in governing their own affairs as provincial residents. The following issues arise from this situation.

6.1 Devolution to the Territorial Governments

Federal policy has evolved over the last ten years to the point that the current government's position favours an organized, gradual transition of legislative authority over northern land and resources to the territorial governments (see: Canada, DINA; 1985). This position is welcomed by the territorial governments, but disputes are still likely to occur regarding how much authority is transferred over which resources, and how soon.

The Government of the Northwest Territories has recently advocated that a first step in the transition process be the transfer of authority over water resources. How this could occur is one of the subjects dealt with in that government's submission to the Inquiry.

6.1.1 Conclusions and recommendations

An idea that has been brought forward regarding the devolution of water management responsibilities from federal to territorial governments is to initially make the Water Boards responsible to both levels of government under a system of "mirror" legislation and regulations. Eventually, this accountability would be solely with the respective territorial governments.

To pursue this strategy, Thompson (1984) notes that regulation of wastes is within the jurisdiction of the territorial legislatures under heads of power defined in the Yukon Act and Northwest Territories Act. These heads of power are (as defined in s. 13 of the Northwest Territories Act): the licensing of business, industry, etc; establishing rules regarding property and civil rights; regulating agriculture; and regulating matters of a local and private nature. Consequently, the territorial legislatures are legally competent to enact legislation regulating waste discharges into water, providing that such legislation does not conflict with any federal statutory provisions.

Thompson (1984) goes on to say that territorial legislation regarding waste disposal in water could include provisions that parallel those of NIWA in so far as they relate to water quality, and could recognize the same Water Boards and the same definitions, powers and procedures as contained in NIWA. In this way, the territorial governments could adopt the Water Boards as their own

agencies, have Water Board licences issued as territorial as well as federal licences with respect to water quality, have additional provisions added to the territorial licences, and even require territorial licences in cases where federal licences are not now required. The federal government may support such action, as it could be seen as an appropriate transitional measure toward increased territorial self government.

Finally, the appropriate territorial agencies could gradually take over administrative and enforcement duties from regional DINA authorities by first becoming involved in enforcing their own water quality licences. As expertise and funds increase, full administrative responsibilities over water resources could be adopted.

6.2 Federal Policy on Interjurisdictional Matters

Given the federal governments' current dominant role in managing the North's water resources, it is of more vital concern to northerners than perhaps to provincial residents that the federal government have a workable policy regarding its role in interjurisdictional affairs. Both territories are apprehensive about the present or potential impacts of water use in other jurisdictions as both share major river basins with the western provinces. Therefore, the territorial governments advocate that the federal government take a more active role in interjurisdictional affairs.

The same problem arises here, though, as is encountered when considering the federal government's role in interprovincial water matters. What is the nature of that role? Certainly the federal government has a duty to represent territorial interests, but does it, in the national interest (of which protecting northern water resources may be a part), have a larger role to play?

6.2.1 Territorial involvement

Recent events in the NWT indicate that territorial concerns are not entirely dependent on the federal government for representation in interjurisdictional matters. The Alberta and federal governments began discussions regarding the impacts of Alberta's proposed hydroelectric development on the Slave River in 1982. The Slave is a major tributary of the Mackenzie River system, and a major development on it would have repercussions not only in the downstream portions of the Slave in the NWT but also along the entire Mackenzie River Valley.

Initially, DINA was willing to allow the Government of the NWT (GNWT) observer-status at any interjurisdictional negotiations. However, the GNWT advocated independent participation as a signatory on the basis that, as the body elected by the people of the NWT, it is the proper representative of the community and of regional interests that would be affected by upstream development. Alberta supported the GNWT's participation as a negotiating and signatory body, agreeing that the GNWT best represents the region's

interests. Perhaps Alberta anticipates that the GNWT will eventually acquire jurisdiction over water resources in the territory, and wishes to ensure that any agreements signed now would not be disavowed by a future NWT government.

As a result, the GNWT has been granted signatory status in both the negotiations with Alberta and the negotiations with other provinces towards a master agreement for the Mackenzie River Basin. The federal government remains a major player in any agreement, partially because of its jurisdiction over northern resources, but also due to its constitutional responsibilities for navigable waters, fisheries, national parks, and inter-provincial undertakings. However, the fact that the GNWT has signatory status regarding agreements for tributaries entering the NWT heightens its profile in water use management, as well as improves the chances of local and regional concerns influencing the nature of these agreements.

6.2.2 Interjurisdictional agreements

Both territories, as noted, share major sources of water with several provinces. Obviously, to make efficient yet equitable use of these shared resources, cooperation among these jurisdictions in their management is essential.

In the case of the Mackenzie River Basin -- which is shared by both territories and three western provinces -- an agreement was

signed in 1978 in which the governments of Canada, B.C., Alberta and Saskatchewan agreed to cooperate in a three-year study program aimed at gaining a more comprehensive understanding of the physical, biological, and hydrological characteristics of the Basin. The report documenting the results of the study was published in 1981. Its first recommendation stated:

> "that the jurisdictions at an early date conclude an agreement through which trans-boundary water management issues such as minimum flows, flow regulation, and water quality can be addressed...and which establishes a permanent board to implement the provisions of the agreement." (MacKenzie River Basin Study , 1981:x)

To this end, two conferences have occurred to exchange information and ideas among government representatives and others in the field of water management and interjurisdictional policy development.

The second workshop-conference, held in May 1983, produced an "Agenda for Action" which called upon the six governments "to move, as a matter or urgency...and conclude a formal agreement or compact on the cooperative management of the water resource (of the MRB)." This Agenda stated that the agreement should provide "an umbrella" under which the details of coordination could be worked out. (Sadler, 1984).

Currently, the various governments are pursuing bilateral agreements, each between the two jurisdictions encompassing a particular tributary or portion of the Basin that is of

common concern. This process means that the precedents for a future master agreement will be set by the terms of the bilateral agreements rather than vice versa, which is the reverse of the process envisioned by the two conferences that debated this issue.

As yet, negotiations of the terms of these bilateral agreements have not yet begun. Discussions among the Alberta government, DINA, Environment Canada and the GNWT regarding the Slave River are characterized as still being in a "pre-negotiation phase", where the parties involved are attempting to develop a common data base regarding flow characteristics, water quality, etc. to which all parties agree, and from which negotiations can then begin. Negotiation of the terms of the agreement itself are not expected to begin for another year (Inquiry on Federal Water Policy, 1984: 23).

6.2.3 Conclusions and recommendations

Little can be added to what has already been debated and suggested to the Inquiry regarding the federal government's constitutional and political role in interjurisdictional affairs (see: Rueggeberg and Thompson, 1984b). As for the involvement of the territorial governments, the present status of the GNWT in agreements regarding the Mackenzie River Basin improves representation of territorial concerns as well as raises the government's profile in water management. Such moves are to be

encouraged in the transition to increased territorial jurisdiction over resources.

6.3 Division of the NWT

Division of the NWT is not a new topic. It was seriously considered but recommended against in the report of the Carruthers Commission in 1966. The Dene Declaration of 1975 and the Nunavut proposal of the Inuit of the eastern Arctic in 1976 stated these native people's desire for separate, autonomous regional governments. Much of the current movement to divide the NWT originated in the eastern Arctic where the residents felt far removed from the territorial government in Yellowknife.

On April 14, 1982, the people of the NWT voted in a plebiscite in favour of dividing their land into two separate political entities -- an eastern territory and a western one. The federal government has agreed in principle to this division, provided that certain conditions are met. A Constitutional Alliance, comprised of several members of the Legislative Assembly and leaders of the four major aboriginal organizations in the NWT, was formed in 1982 to actively support the call for division. Part of its mandate is to select an appropriate boundary and to submit its choice to the public for consideration and approval. It is also responsible for reaching consensus and public ratification of proposals for political and constitutional development for each newly-formed territory. The Alliance formed two sub-groups; a Western

Constitutional Forum (WCF) which would deal with these issues in the western region, and a Nunavut Constitutional Forum (NCF) to serve the east.

On January 14, 1985, the Constitutional Alliance announced "Principles of Agreement" which include a tentative boundary from the 60th parallel to the south-east corner of the COPE claim area of the Inuvialuit and then northward along the eastern border of the Inuvialuit Settlement Region. The agreement, however, fell through in February when disputes emerged again between the two Forums over the process by which the location of the boundary was determined and the implications of the agreement for the Inuit communities (who did not support the proposed boundary) located around the Beaufort Sea. At the moment, the status of the negotiations is uncertain.

6.3.1 Conclusions and recommendations

Division of the NWT could create the same upstream-downstream problems on rivers flowing across the new boundary as are now experienced among the provinces. These problems are exacerbated by the vagueness of Canadian law respecting reciprocal rights and duties respecting upstream and downstream jurisdictions. If water licensing and management is also split, planning and management on a basin-wide basis, which the Water Board and DINA authorities have had the freedom to do for many river systems in the NWT, becomes very difficult.

One must recognize, however, that the lands of the NWT are subject to land claims settlements, and that division will likely not occur until these are completed. Given the combined effect of jurisdictional devolution, political division, and the settlement of three comprehensive land claims, the potential for a mosaic of partially or totally independent jurisdictions each with its specific rights to resources (including water) and its own managing institutions, becomes apparent. Under these circumstances, water management in the future appears to be up for grabs.

In the interests of comprehensive water ,management, and assuming that water management is handled territorially by the time formal division takes place, the governments of the separate territories formed by dividing the NWT might consider retaining a single Water Board for both new territories, with a mandate to manage watersheds according to principles shared by both jurisdictions as if no boundary existed. As an alternative, each jurisdiction could authorize its own Board to form a joint Board with the other to deal with water issues occurring at the new boundary. An agreement providing for such an arrangement should be formulated, and would specify a process for arriving at mutually agreeable management principles regarding water quality and allocation. As a third alternative, boundary water disputes could be handled by an agreement similar to the International Boundary Waters Treaty, which defines a process for arriving at solutions for individual water issues as they arise. (These recommendations are based on ones made to the Constitutional Alliance in Rueggeberg and Thompson, 1984.)

As a final option, a recent study (Foster, 1984) proposes dividing the NWT along natural water shed boudaries. In the south-central NWT, this natural boundary would be the height of land between the watersheds of Hudson Bay and the Mackenzie Basin. The boundary could be extended northward along lines of watershed to the west of the Thelon Game Sanctuary and the Queen Maud Bud Sanctuary. Foster (1984:ii) claims that such a dividing boundary "responds directly and positively to the problems inherent in division of the Territories and best meets the principles established for dividing the Northwest Territories into Nunavut and the Western Arctic."

VII. WATER DIVERSION AND EXPORT

There is an underlying attitude among some water managers that northward-flowing rivers are being wasted as they flow through the vast, empty north lands to the Arctic Ocean. Many would like to harness or divert that water for use in southern, water-short regions of Canada and the United States.

Some inter-basin transfer has occurred on a small scale in the territories, particularly Yukon, for hydro-electric generation. Damming resulting in diversion and inter-basin transfers in the upstream portions of several north-flowing rivers is being contemplated. The Slave River hydroelectric project proposal in Alberta has already been described. Controversy continues to flare intermittently over Alberta's consideration of inter-basin water diversion from the Peace-Mackenzie to the Saskatchewan-Nelson System to feed the irrigation and consumptive needs of the southwest (Sadler, 1983). Two other proposed projects involve diverting the headwaters of the Yukon River into rivers that flow through the Alaska Panhandle for generating hydroelectric power, the Yukon-Taiya diversion which would generate power in Alaska and the Yukon-Taku diversion generating power in B.C. (Fox et al., 1983).

The major arguments against these proposals are twofold. One involves the many environmental impacts of such massive changes in

these river systems, some of which could be surmised from previous projects (e.g. the Bennet Dam) but many of which are unknown. The other deals with the social, economic and cultural effects on downstream users in the territories, an issue that is particularly acute given that in most cases these users are at a disadvantage by not being in the same political jurisdiction as the proposed project. In most cases, it is not enough to ensure that sufficient water is left to fill the needs of these downstream residents, because the very wild nature of these rivers is an important part of the traditional lifestyle of many Northerners and of the national heritage of Canada.

7.1 Conclusions and Recommendations

Determining the economic and technical feasibility of diversion and export of northern waters is beyond the scope of this report. Determining its desirability is a political matter, and the reader is directed to the submissions made to the Inquiry for the opinion and feelings of northerners on this issue.

VIII. SUMMARY OF RECOMMENDATIONS

Protecting Natural Conditions and Instream Uses

- Proposals put forward by the territorial governments, the regional Water Resource Divisions of DINA, and the Inland Waters Directorate for comprehensive data collection and monitoring programs of northern hydrological systems should be supported.

- A number of measures for providing greater protection to instream uses have been suggested. These are:

  1) incorporating minimum flow terms into all water licences.
  2) issuing licences to government agencies under "a use for conservation purposes" prescribed in the NIWA Regulations, for the purpose of maintaining minimum instream flows and unimpaired water quality.
  3) using the power allotted to the Water Boards under s. 14 of NIWA to make recommendations to the Minister of DINA regarding reservation of land and water rights in the interests of protecting instream uses.
  4) adding traditional instream uses as a water use classification in s.5 of the NIWA Regulations, thereby permitting these uses to be licensed.

5) amending NIWA to recognize long-standing traditional water uses by requiring that all licences include conditions for maintaining minimum stream flows and providing for appropriate compensation measures for instream users who can prove long-standing use.

Placer Mining

° The recommendations of the Yukon Placer Mining Guidelines Review Committee should be more closely examined. Special attention should be paid to recommendations to:

1) make the Water Board the "single window" for regulating placer mining.

2) resolving regulatory conflict and confusion by making the regulatory regimes under the Fisheries Act and NIWA, more consistent.

3) examine the guidelines themselves to see how they could be gradually adapted for use by the placer mining industry.

° The present industry-government committee should be encouraged to follow through on these aspects of the Review Committee's recommendations along with their current emphasis on mining research and development.

Abandonment of Industrial Wastes

- The technology behind industrial waste abandonment in northern climes needs greater attention so that a concrete definition of "satisfactory" abandonment measures can be approached.
- The use of security bonds in providing for mine abandonment, and the long-term responsibility of the licencee for abandoned waste, even after the licence has expired, must be clarified in NIWA.
- Efforts by the territorial governments and the Water Boards to regulate waste abandonment should be coordinated.

Regulating Lesser Water Uses

- A process for issuing permits for relatively small, routine water uses that is less rigorous and time-consuming than the current licencing process should be established under NIWA. Such a permitting process should be carried out under the jurisdiction of the Water Boards such that whoever reviews and issues permits is responsible to the respective Board rather than to DINA. Permits should have the same legal status as licences. While public hearings would not be required, permit applications and the reasons for decision by the permit-issuing authority should be publicly available.

- A close examination of the administrative procedures and other operational aspects of the Yukon Water Board's Expedited

Procedures for licensing placer mining may be useful in developing a permitting process.

Water Quality Standards and Water Use Priorities

° These terms should be defined in NIWA or its Regulations so as to provide them statutory recognition. The definitions, however, should allow flexibility and discretion in the application of standards and priorities by the respective Water Boards. A way of defining these terms as guidelines is suggested.

° Standards and priorities should be derived and implemented through a planned approach to water licensing.

Compensation

° If amendments to NIWA are contemplated, they should provide for clear compensation measures (especially the relationship of compensation to security bonds) for prior licences and for traditional (non-licensed) users who suffer injury as a result of another, licensed use. The appropriate form and means of measurement of compensation, especially for traditional or instream uses, need careful study.

° If amendments to NIWA are not contemplated, the Water Boards do not presently have the legal support to implement

appropriate compensation programs. In this case, the Boards and water users must rely on the courts or look to government policies like the GNWT's Renewable Resource Compensation Policy.

Planning for Licensing

° A conclusion of this report is that the Water Boards have a mandate to take a long-term view of their licensing activities. A three-part planned approach to licensing is suggested which would see:

1) the establishment of water management objectives on territory-wide and eventually area-specific bases via a public process;
2) the derivation of guidelines for water quality standards and water use priorities that could be adopted as Water Board policy, Water Board procedural rules, or as regulations under NIWA as previously suggested;
3) the implementation of these guidelines by the Water Boards in deciding whether to issue a given licence and the appropriate terms and conditions to be incorporated.

Integration with Land Use Planning

° There are several ways in which planning water use could be incorporated into or coordinated with land use planning efforts. One method suggested is for land use planning commissions (or other agencies set up by federal or

territorial governments) to invite input from the Water Boards or to request the appropriate Board to hold a public hearing regarding water use objectives for a given planning area. This approach would be especially applicable if the Water Boards adopt a planning-for-licensing strategy, as previously recommended. The water management objectives derived under such a strategy would be useful to any land use planning efforts; similarly, land use planning priorities could indicate which areas should be the focus of the Water Board's effort.

° Other useful measures for integrating land and water use planning are having technical staff common to water licensing and land use planning operations, and choosing planning areas based on watersheds and natural basins. These measures would help ensure that water use principles arse incorporated into land use planning.

Aboriginal Rights and Comprehensive Land Claims

° Water policy makers must recognize that substantial impacts on future water management regimes in the North will result from definitions of aboriginal rights and native self government and their incorporation in the Canadian Consitution, and the settlement of comprehensive land claims.

Territorial Devolution

- The management of water resources may begin to be transferred from federal to territorial control as one step in a chain of events leading to total government devolution. (This step has already been proposed for the NWT). This transfer could occur by adopting territorial legislation that mirrors NIWA. This legislation, along with concurrent amendments to NIWA, would make the Water Boards responsible to both federal and territorial governments. This legislation could also capitalize on present territorial fields of jurisdiction and take greater control of water quality management. Eventually, all aspects of water management, including full authority over the Water Baords, could be passed to the territorial governments.

Interjurisdictional Matters

- While the federal role in interjurisdictional affairs is ill-defined, the federal government has a duty to represent northern (not just federal) interests in any disputes regarding water resources shared by the provinces and the territories.
- Nevertheless, the territorial governments, should be encouraged to insist on equal status in any discussions or agreements regarding shared water resources.

Division of the NWT

- Division of the NWT could lead to problems in managing water basins bisected by a political boundary, similar to problems already faced among provinces and between provinces and territories. Such problems could be limited by such measures as providing for joint water management institutions (e.g., a joint Water Board, or agreements for water resource sharing), or by choosing a boundary which avoids crossing major water basins.

BIBLIOGRAPHY

1. Canada, Government of 1984. Placer Report Now Available; Whitehorse, Yukon (January 18, 1984). News Release # 1-8344.

2. Canada, Indian and Northern Affairs Canada. 1984. The Western Arctic Claim. The Inuvialuit Final Agreement. INAC, Ottawa. 115p.

3. ______. 1985. Notes for remarks by the Honorable David Crombie, P.C., M.P., Minister of Indian Affairs and Northern Development to the Legislative Assembly odf the Northwest Territories, Yellowknife, Feburary 6, 1985. 15p.

4. Ferguson, Simek, Clark Ltd. 1983. An Investigation of Possible Small Hydro Generating Sites in Northwest Territories Communities. Science Advisory Board of the Northwest Territories. Yellowknife. 65p.

5 Foster, M. 1984. A Natural Boundary to Divide the Northwest Territories. Prepared for the Northern Canada Power Commission. 12p.

6. Fox, I.K. 1984a. An assessment of legal and administrative arrangements related to placer mining in the Yukon River Basin. Report prepared for the Yukon River Basin Study. 22p.

7. ________. 1984b. An assessment of institutional arrangements in the Yukon River Basin for planning, constructing and operating hydroelectric power facilities. Report prepared for the Yukon River Basin Study. 29p.

8. ________, P.J. Eyre and W. Mair. 1983. Yukon Water Resources Management Policy and Institutional Issues. Westwater Research Centre. Vancouver. 52p.

9. Mackenzie River Basin Committee. 1981. Mackenzie River Basin Study Report. Summary. Inland Waters Directorate, Environment Canada.

10. MacLachlan, L. 1984. Legal Issues Concerning Northern Water Resources. Appendix in: Rueggeberg, H. and A.R. Thompson. Water Law and Policy Issues in Canada. Westwater Research Centre, Vancouver. 153p.

11. MacTavish, J.S. 1983. The Territorial Water Boards and Issues Concerning their Operation. Report prepared for the Dept. of Indian and Northern Affairs. 79p + appendices.

BIBLIOGRAPHY (continued)

12. Queenstake Resources Ltd. 1984. Submission to Inquiry on Federal Water Policy, September, 1984. 9p.

13. Pearse, P.H. 1982. Turning the Tide: A New Policy for Canada's Pacific Fisheries. Final Report of the Commission on Pacific Fisheries Policy. Min. Supply and Service. Ottawa. 292p.

14. Rueggeberg, H. 1985. Water Planning and Management in the Mackenzie River Basin. Draft.

15. ______ and A.R. Thompson. 1984a. Resource Management Boundary Problems. Western Constitutional Forum. Yellowknife. 111p + appendices.

16. ______. 1984b. Water Law and Policy Issues in Canada. Westwater Research Centre. Vancouver, 153p.

17. ______. 1984c. A Conservation Ethic in the North: are Institutions in the Way? A paper prepared for the Canadian Arctic Resources Committee. 63p.

18. ______ 1984d. Water Quality and Priorities in the Northwest Territories. Study prepared for the Water Board of the Northwest Territories. 119p. + appendices.

19. Ruitenbeek, H.J. Resources Consulting Ltd. 1983. Keewaten Region - Economic Base Study.

20. Sadler, B. (ed.) 1983. Water Policy for Western Canada: The Issues of the Eighties. Univ. of Calgary Press. Calgary. 203p.

21. ______. 1984. Institutional Arrangements for Water Management in the Mackenzie River Basin. Univ. of Calgary Press. Calgary. 125p.

22. Thompson, A.R. 1984. Environmental Protection Legislation for Northwest Territories. Unpublished report prepared for Justice and Public Services, Government of Northwest Territories. 15p. + appendices.

23. ______ and A. Ourom. 1984. Legal and Administrative Arrangements for Yukon River Basin Water Management. Report prepared for the Yukon River Basin Study. 84p.

24. ______ and H. Rueggeberg. 1984. Water Management in the Yukon Territory. Integration with Land Use Planning. Report prepared for the Yukon River Basin Study. 40p.

LEGISLATION

1. Canada. Arctic Waters Pollution Prevention Act. R.S.C. 1970 (1st suppl.), c.2.

2. ______. Canada Water Act. R.S.C. 1970 (1st suppl.), c.5.

3. ______. Fisheries Act. R.S.C. 1970, Chap. F-14 and subsequent amendments.

4. ______. Northern Inland Waters Act. R.S.C. 1970, c. 28 (1st suppl.).

5. ______. Northern Inland Waters Regulations. Cons. Regs. Can. 1978. c. 1234.

6. ______. Northwest Territories Act. R.S.C. 1970, Chap. N-22 and subsequent amendments.

7. ______. Ocean Dumping Control Act. S.C. 1974-75, c. 55.

8. ______. Yukon Act. R.S.C. 1970, Chap. Y-12 and subsequent amendments.

9. ______. Yukon Placer Mining Act. R.S.C. 1970, Chap. Y-3 and subsequent amendments.

Inquiry on Federal Water Policy
Research Paper # 13

THE SAINT JOHN RIVER: DETERIORATION AND RESTORATION

by

Owen V. Washburn

Washburn & Gillis Associates Limited
April 1985
Fredericton

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn

Frank Quinn
Director of Research

Abstract

The report traces developments in the Saint John River Basin from the end of World War II to the present. The impacts of industrialization and economic development on the water resource are considered along with the efforts of governments to restore a balance of water resource uses. Recommendations are made for the continuing role of federal and provincial governments in management of the water resources of the Saint John River Basin.

Résumé

Ce rapport retrace l'évolution du bassin de la rivière Saint-Jean de la fin de la deuxième guerre mondiale jusqu'à nos jours. Les effets de l'industrialisation et du développement économique sur la ressource eau sont examinés, de même que les efforts faits par les gouvernements afin de redonner un équilibre aux différentes utilisations de l'eau dans ce bassin. Des recommandations sont faites quant au rôle que les gouvernements fédéral et provincial doivent continuer à jouer dans la gestion des ressources en eau du bassin de la rivière Saint-Jean.

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1.0 INTRODUCTION

The Saint John River is an important physiographical feature in the Province of New Brunswick and in the context of the Atlantic seaboard. Its watershed comprises thirty-eight percent of the area of the Province of New Brunswick. The boundary between Canada and the United States for approximately 212 km is formed by the Saint John River. Thirty-six percent of the river's watershed area is in the State of Maine. Thirteen percent of the watershed is in the Province of Quebec and the remainder (fifty-one percent) is in New Brunswick (Saint John River Basin Board, 1975). (See Figure 1)

Like many large rivers, the Saint John has provided an attraction for human settlements and industries. These have contributed to the inevitable resource use conflicts. An obvious example is the conflict between hydro-electric power dams and the migratory requirements of anadromous fish such as the Atlantic salmon. The resolution of water use conflicts is an essential goal of water management and must be considered in both planning and regulation. Regulatory controls, related to both land and water-based activities, are available to governments to manage water use. Regulatory authorities with jurisdiction over water uses in the Saint John River Basin are: various municipalities, the provincial governments of New Brunswick and Quebec, the State of Maine, and the national governments of Canada and the United States.

Planning studies, as well as regulatory efforts, have often been coordinated through inter-governmental committees. In 1969, the Atlantic

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FIGURE 1

SAINT JOHN RIVER BASIN

Development Board, an agency funded by the federal and Atlantic provincial governments, prepared a study on the water resources of the Atlantic Region which included a report on the Saint John River. This report identified the potential for development and some of the problems of water quality degradation. A comprehensive river basin planning exercise was undertaken over the period 1970-1974 by the Saint John River Basin Board. The board was a joint undertaking of the federal government and the Province of New Brunswick. In addition to a final report which identified issues and presented a framework for management, a number of sector reports were published. These provide an important information source of the physical, biological and socio-economic resources of the river basin up to 1973.

In addition to these studies, several inter-governmental committees have been active, and are still active, in coordinating regulatory and planning activities (e.g., The International Saint John Water Quality Committee, The Saint John River Basin Hydrology Committee, The Canada-New Brunswick Flood Damage Reduction Steering Committee).

The present paper has been commissioned by the Inquiry on Federal Water Policy as a case study on the Saint John River, its degradation and restoration from the post-World War II period up to the present. This study was commissioned in order to provide a case history of a river basin in Canada which has experienced developmental pressures resulting in water quality and quantity stresses but which has at least partly recovered through co-operative inter-governmental and government-industry programs.

The objectives of the paper are to review stresses on the water

environment created during postwar economic development of the Saint John Basin; and to assess progress of and remaining needs for intergovernmental co-operation in restoring a satisfactory balance among water uses.

The statement of work prescribed in the contract is as follows:

1. Review post-World War II developments in the Saint John Basin, with emphasis on forestry, agriculture, energy projects, resource-processing industry and growth of urban communities and their impacts on the basin's water resources, e.g., flow control, erosion and sedimentation, waste discharges, flooding, aquatic habitats;
2. Describe the major intergovernmental programs, with an emphasis on the value of river basin planning, which have focussed on Saint John waters and water use issues over the past two decades, including those of the Atlantic Development Board, Saint John River Basin Board, International Saint John Water Quality Committee, Saint John River Basin Hydrology Committee, and Canada-New Brunswick Flood Damage Reduction Steering Committee, and assessing generally what has been achieved and what issues remain outstanding; assessing in particular why certain recommendations were not carried out;
3. Assess in particular the progress of clean-up resulting from government-industry negotiations, court actions and (community) assistance programs throughout the Canadian portion of the Basin; and the impact of presently untreated wastes, e.g., Florenceville, Edmundston.
4. Recommend measures for improving water management or acceleration remedial programs in the Saint John Basin which bear upon federal responsibility and performance.

Although the Saint John River Basin is in two provinces, New Brunswick and Quebec, as well as the State of Maine, this paper concentrates on the New Brunswick portion of the Basin without ignoring interprovincial or international concerns. There are several practical reasons for this approach. Planning studies such as that of the Saint John River Basin Board have focused on the New Brunswick portion of the river. Much of the economic data is aggregated at a provincial level. While this allows meaningful extrapolations to be made to the Basin in New Brunswick, a similar extrapolation would not be meaningful in Quebec since the Basin represents such a small part of that province. A significant portion of the Basin is in Maine. While water quality of tributaries entering New Brunswick from Maine has been considered, regulatory and planning aspects which would affect these tributaries are outside the mandate of the Government of Canada and, therefore, have not been considered except in the context of international committees.

1.1 Physical Description of the River

The Saint John River is approximately 700 km long. It flows from Little Saint John Lake on the boundary between Maine and Quebec to the point where it empties into the Bay of Fundy at Saint John, New Brunswick. Its watershed encompasses 54,900 sq km. The headwaters of the river are in the Notre Dame Mountains of Eastern Quebec and the Chaleur Uplands of Northern New Brunswick and Northern Maine. Its highest point of elevation is about 480 m above mean sea level at Little Saint John Lake. The river bed reaches mean sea level just above Fredericton, 80 km from its mouth. Major tributaries of the Saint John River include the Aroostook (drainage 6,275 sq

km), the Tobique (drainage 4,325 sq km), the Salmon (drainage 3,885 sq km), the Allagash (drainage 3,260 sq km, and the Madawaska (3,050 sq km).

The mean annual precipitation varies from about 89 cm in the headwaters to about 140 cm near the Bay of Fundy. In the northern and western portions of the Basin annual snowfall is 250 to 350 cm, and in the southeast it is 180 to 200 cm. The annual average discharge of the Saint John River, measured at Pokiok gauging station, is 728 m^3/sec with a maximum of 1,149 m^3/sec and a minimum of 467 m^3/sec having been recorded. Although the timing of high and low flows varies from year to year, high streamflows or floods usually occur in April or May. There are typically two usual periods of low flow: late summer (August to October) and mid-winter (February).

1.2 Historical Uses of the River

Before the arrival of Europeans, the Saint John River was used by the native Indian population as a means of transportation, as well as an important source of food through its support of an abundant fish population. The floodplains of the river provided areas for settlement, agriculture and hunting. For these same reasons early European settlers concentrated their activities along the river. By the end of the seventeenth century the Acadians had begun settling the lower Basin between Fredericton and Saint John. The uses of the river system by early Europeans were not markedly different from those of the indigenous population, except that agricultural activity was expanded and water was used to power grist mills. With the fall of Acadia in 1758 the French settlers were replaced by New Englanders.

Up to 1783 their numbers remained small and their uses of the river were similar to the Acadians.

The intensive settlement of the Saint John River Basin began in 1783 with the arrival of the United Empire Loyalists at the close of the American War of Independence. By 1806, the population of New Brunswick had increased to 35,000 and many of the new arrivals settled in the Saint John River Basin. Not only did numbers increase, but settlement expanded up the river. Natural population increase and extensive immigration, particularly from the British Isles, increased the population by about forty times over the next 150 years (Statistics Canada, 1984). The population of the New Brunswick portion of the Basin was 160,000 by 1901, and 231,000 by 1951 (Saint John River Basin Board, 1975).

Water-driven mills probably created the first impacts on the river system's natural environment, since they resulted in many small tributaries being dammed thus blocking fish migration. With the creation of stable settlements the importance of the river as a transportation system greatly increased. The river was, in fact, the most important means of transportation in the Basin until road and railway systems were created in the nineteenth century.

By the end of the 17th century, forestry had become an important economic activity in the Basin. New Brunswick white pine became a source of spars and masts for the French navy (as they did for the British navy two generations later) (Tweeddale, 1974). Stream driving, a part of early

forestry operations, produced the first widespread impact on water quality. Bark and wood from log holding areas also contributed to the physical degradation of aquatic habitat. Stream driving on the Saint John River system continued on the main stem until the construction of Beechwood Dam, and on some tributaries (for example, the Nashwaak) at least until 1969 (T. Fellows, personal communication, 1985).

Waste disposal was not a concern of early settlers. The dilution and disposal of domestic wastes were not important uses of river waters until communities began collecting and disposing of their sewage at a central point. Early waste disposal practices did, however, undoubtedly lead to the contamination of groundwater. With the development of process industries, e.g., pulp and paper mills, the disposal of industrial wastes became an important determinant of surface water quality.

The first use of the Saint John River System for hydro-electric power generation was in 1904 when a station was constructed on the Meduxnekeag River to serve the town of Woodstock. Other plants were constructed in the early part of this century at Tinker Falls, Squapan and Caribou on the Aroostook River in Maine, and on the Madawaska and Green Rivers in New Brunswick. The first hydro-electric facility on the main stem of the river was built at Grand Falls in 1928 (Sigvaldason, 1975).

1.3 Post World War II Conditions in the Basin

1.3.1 Development in the Basin

In 1951 the population in the New Brunswick portion of the basin was 231,000. Of this number, 42,000 lived in northwestern New Brunswick

(Grand Falls and above), 39,000 lived between Grand Falls and Fredericton, and the remainder lived in Fredericton and below, including the city of Saint John (Saint John River Basin Board, 1975). The economy of the middle and upper Basin was dominated by forestry and agriculture. In Edmundston, for example, the main industry was the Fraser Companies Ltd. pulp and paper mill. Many other communities, such as Plaster Rock, depended on sawmills. Although the food processing industry was not built up until the 1950's, agriculture provided the economic base for many of the communities in the Basin.

The only area in the Basin for which mining was a significant economic activity was the Minto-Chipman area, where coal was mined. The cities of Fredericton and Saint John were major service areas in the southern portion of the Basin. Saint John was also the most important manufacturing area in the Basin.

1.3.2 Waste Loading and Water Quality

At the end of World War II, the awareness of environmental problems, including the impacts of releases of untreated domestic and industrial wastes on aquatic systems, was not as well developed as it was to become in the next few decades. Therefore, waste loadings were not well documented, nor were extensive water quality surveys made.

The first widely published water quality survey on the Saint John River was undertaken in 1960 (Department of National Health and Welfare Canada, 1961). An indication of the state of pollution of the river at that time is shown in the following which is taken from the synopsis of their report.

> "This report indicates that conditions, resulting from pollution in the international reach of the river between Edmundston and Grand Falls, represent gross pollution. The effects of chemical pollution in this section produced average values of dissolved oxygen below the "objective" of 5 p.p.m. and minimums of 0.0 p.p.m. which resulted in fish kills which were observed and recorded. Sewage, contributed to the river, creates grossly polluted conditions below each major centre of population. A physical and chemical pollution problem existed at East Florenceville due to waste discharges from a food-processing plant."

In 1946 similar conditions to these would be expected to have existed for the reach from Edmundston to Grand Falls and immediately downstream of major municipalities. Below East Florenceville water quality problems probably did not occur before the opening of the McCain Foods Limited plant in 1957.

1.3.3 Flow Regulation and Hydrology

At the end of World War II there was only one hydro-electric plant (Grand Falls) on the main stem of the river. In the Canadian portion of the basin there were also small hydro-electric developments on the Madawaska River at Edmundston (2,000 kw capacity) and on the Green River at Second Falls (1,200 kw capacity) (see table 1.1 from Sigvaldason, 1975). In Maine there were dams at Tinker and Caribou. Montreal Engineering Company Limited (1969) lists 88 dams on the New Brunswick portion of the Saint John River. Approximately half of these were in existence in 1946. Most of these were small dams on tributary streams which were used for recreational purposes or forestry operations. Very few, however, had fish passage facilities.

2.0 DEVELOPMENT IN THE BASIN

In his book on Environmental Management MacNeill (1971) states,

> "The genesis of environmental deterioration is to be found in increased population, urbanization, industrialization and technological innovation and their derived products."

All of these factors have contributed to pressures tending to degrade the water quality of the Saint John River system and place limitations upon the uses of the resource. As development increased, more and more wastes entered the water courses and problems with river flooding became more acute particularly on developed river floodplains. In the following sections, development activities in the Basin, particularly in regard to interactions with the river water quality and flow regimes, are described.

2.1 Changes in Population, Economic Activity and Land Use

The post-war boom years in North America were reflected in changes in economic activity in the Saint John River Basin. From 1951 to 1971, the population of the Basin increased from 231,000 to 299,000, an increase of nearly 30 percent (Saint John River Basin Board, 1975). During the same 20-year period, the population of New Brunswick increased by 23 percent and Canada as a whole by 54 percent (Statistics Canada, 1981a).

In Canada, since World War II, the population has shifted from rural to urban. In 1951, for example, 62 percent of the population was urban whereas in 1981, 76 percent was urban (Statistics Canada, 1981b). During the same period, New Brunswick has shifted from 42 to 51 percent

urban. Changes in the population of municipalities in the New Brunswick portion of the basin are shown in Table 2-1. The figures are difficult to interpret because of amalgamations and boundary changes, nonetheless the data show that some municipalities have experienced little or no growth (e.g., Hartland) while others, such as Fredericton, have experienced more substantial growth. In fact, most of the growth has been centred in the larger urban centres of Saint John and Fredericton.

TABLE 2-1

POPULATION CHANGES IN MUNICIPALITIES IN THE BASIN

(Statistics Canada, 1984)

Municipality	Population 1951	Population 1981
Edmundston	10,753	12,044[1]
St. Leonard	1,419	1,566
Grand Falls	2,365	6,203[1]
Hartland	1,000	846
Woodstock	3,996	4,649[1]
Fredericton	18,170[2]	43,723
Oromocto	661[3]	9,064
Sussex	3,224	3,972[1]
Saint John	50,779	80,521[1]

Notes:
1 Includes boundary change
2 Marysville added to 1951 figure
3 Figure for 1956 used for Oromocto

Urbanization tends to create pollution problems by concentrating waste loadings at outfalls rather than dispersing the waste as would be the case, for example, with septic tanks. More paved streets and parking lots also change the characteristics of run-off and contribute to run-off related water quality problems.

Related to changes in population were changes in economic activity. Table 2-2 shows some comparative statistics for New Brunswick for the period covered by this report. Similar trends would be expected for the basin.

TABLE 2-2

INDICATORS OF ECONOMIC ACTIVITY SINCE WORLD WAR II

Indicator	Beginning of Period	1983
Employment	163,000[1]	247,000
Salaries and Wages (thousands of dollars)	201,112[1]	3,870,200
Domestic Exports (thousands of dollars)	11,760[2]	1,667,680
Gross Provincial Product (millions of dollars)	505[3]	6,630[4]

Notes:
1 in 1948
2 in 1970
3 in 1951
4 in 1982

With the exception of the cities of Fredericton and Saint John, the economy of the Basin is based on the production and processing of forestry and agricultural products. Development in these sectors has had a significant impact upon the Basin.

2.1.1 Development of the Forest Products Industries

Several important trends have characterized the evolution of the forest industries in New Brunswick during the past thirty years. These trends, which have a complex cause-and-effect relationship are:

- i) increase of the importance of pulp and paper production in relation to the production from sawmills;
- ii) the expansion of wood-processing facilities with the attendant requirement for greater annual harvest from the forest;
- iii) the mechanization of forest harvesting including clear-cutting;
- iv) the change of log transportation methodology from stream driving and booming to the use of an extensive forest road network;
- v) extensive pest control operations; and
- vi) the development of reforestation programs.

The shift in emphasis in the New Brunswick forest industries from sawlogs to pulp and paper production has been going on for most of this century. At one time there were more than 600 sawmills in New Brunswick with the highest recorded production figure being in 1915. By 1971, there were fewer than 150 sawmills, whereas the number of paper mills had increased to 11. At that time the annual value of pulp and paper products was about $190,000,000 per year compared to $50,000,000 for the products

from sawmills (Tweeddale, 1974). In the past 15 years, the sawmill industry has made a comeback to the point where paper and allied products were 70 percent of the value of forest products (Watson, 1983); down from the 79 percent in 1971 as reflected in the above figures. Similar statistics are not available for the Basin, however, a comparable shift likely took place.

The shift of product emphasis in the forest industry has had significant water management implications. In terms of processing, the waste products from sawmill operations are solid (bark, sawdust and wood residues) rather than aqueous pollutants. Sawmill operations can, however, lead to water quality problems. The two main sources of such problems are hot pond effluents and leachate from log storage and solid waste storage areas. Before environmental awareness was as prevalent as it is today, sawdust and other solid wastes were sometimes disposed of directly in watercourses causing severe local water quality problems and physical degradation of habitat. Sawmills were also often associated with dams which prevented fish migration, particularly on small tributary streams.

Pulp and paper mills are large users of water and add significant pollution loads to the environment unless effective wastewater treatment is used. Even a modern kraft mill, with a high degree of water reuse, can be expected to discharge 15,000-25,000 gallons (68,000 - 114,000 L) of effluent per ton of product with typical BOD[1] and suspended solids loadings of

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[1]BOD (Biochemical Oxygen Demand) - the amount of oxygen consumed in the biochemical oxidation of organic matter present in water. It is usually measured over a five-day period and is sometimes written as BOD_5.

11 lb/ton (5.5 kg/tonne)(Bruley, 1974). From the same paper, Table 2-3 shows typical waste loadings from various pulp and paper effluents.

TABLE 2-3

BOD LOADS OF SOME PULP AND PAPERMAKING EFFLUENTS

Type of Effluent	Five-Day BOD lb/ton (kg/tonne)
Kraft Pulp	25 - 50 (12 - 25)
Groundwood Pulp	15 - 25 (8 - 12)
Sulphite Pulp (no recovery)	400 - 600 (200 - 300)
NSSC Pulp	250 - 450 (120 - 220)
Bleaching	12 - 200 (6 - 100)
Fine Papers (bond)	20 - 40 (10 - 40)
Coarse Papers (corrugating)	25 - 60 (12 - 30)
Newsprint	10 - 20 (5 - 10)

Source: Bruley, 1974.

In the conspectus of the report of the New Brunswick Forest Resources Study, the rapid increases in forest products processing capacity and its impact on wood harvesting is documented (Tweeddale, op. cit.) . Up to 1968, man was harvesting only about one-third of natural annual growth of wood in the province. In the period 1972 to 1975, mill capacity expansion increased the requirement for wood from 6.2 million cubic metres to 11.9 million cubic metres. This figure exceeded the allowable cut to

maintain stocks when consideration is given to the loss of wood due to natural predation and disease. This trend continued throughout the 1970's and early 1980's. Watson (op. cit.) estimated that in 1983 the production capacity of the forest industry was 3.1 million cunits[1] per year of softwood, whereas the maximum sustainable annual yield, including consideration of forest protection and silvicultural activities, was estimated to be 2.5 million cunits per year of softwood.

The expansion of the forest processing industry has had significant implications on water quality in two ways: the direct impact of greater waste loads to receiving waters and the impacts of more intense forestry operations. When only a fraction of the annual growth of wood was required, traditional forestry practices were adequate to meet demand. With the demand from processing industries exceeding the sustainable annual yield, and with much of the forest in a mature state, the use of mechanized harvesting as well as silvicultural and forest protection programs became imperative.

The mechanization of forestry operations affected the intensity of cutting activities (clear-cutting versus selective cutting), the harvesting techniques (fellers, bunchers and skidders versus chainsaws and horses), and required the provision of an adequate forest road system to handle heavy equipment and large logging trucks. Potential impacts of forestry

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[1] A cunit is equivalent to 100 cubic ft (or 2.8 cubic metres) of solid wood, measured in the round.

operations on the aquatic environment include: increases in siltation, water temperature, nutrient loadings and discharge peaks. Other concerns include scouring of stream beds and loss of allochthonous organic material.

Impacts are difficult to quantify and the results are sometimes contradictory. For example, Welsh et al. (1977) found that streams in clear-cut watersheds had 17 percent fewer trout, 200 percent more sculpins (*Cottus cognatus*) and 26 percent fewer benthic organisms than control streams. In a different study, Englert et al. (1982) who reported work on the effects of logging on salmonid populations found that areas sampled downstream of clear-cutting and bank modification did not have significantly lower biomass[1] than control areas, while areas downstream of two stream crossings were found to have significantly lower biomass of salmon.

The Nashwaak Experimental Watershed Project was set up in 1970 with the principal objective of determining the effects in a forested watershed of:

1) the prevailing clear-cutting method on water yield, regime and quality, on aesthetics, on wildlife, and on forest and stream productivity;
2) fertilization with a nitrogen-source fertilizer on forest and stream productivity; and
3) spraying with insecticides on stream productivity.

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[1] In Englert et al. (1982), biomass refers to the total weight of salmonids in a given area.

Three watersheds were used in the study. One watershed was treated with fertilizer in 1975 and a second was clear-cut from May 1978 to March 1979. The third watershed was used as a control.

Studies have been ongoing since the inception of the project. Some of the results reported to date (Powell, 1983) are:

1) Minor increases to suspended sediment loads were found to persist in the clear-cut for up to three years after clearcutting.
2) Elevated nutrient levels in water were found in the clear-cut watershed but were thought to be too small to adversely affect plant and animal habitats.
3) Distinct changes in the stream plant community composition were found in the clear-cut watershed.

None of these changes were considered to produce major impacts at this stage of the study.

2.1.2 Development of Agriculture

In the post-war years there has been a general decline in the amount of land farmed as the population moved from rural to urban centres. Between 1951 and 1971, although in the Basin the average farm size increased from 64 hectares to 107 hectares, the area farmed decreased by 53 percent and, in the province as a whole, there was a 62 percent decrease (New Brunswick Department of Agriculture and Montreal Engineering Company Ltd., 1974). This shift to fewer, but larger farms, is emphasized by the following: small farms (farms with sales under $1,200) in 1961 represented

56.4 percent of all farms, and 8.8 per cent of agricultural sales, while in 1971 these farms were 36.4 per cent of all farms and had only 1.9 per cent of total sales (New Brunswick Department of Agriculture and Montreal Engineering Company Ltd., op. cit.). The swing to larger farm size, more specialization and commercialization necessitated changes in management. Along with increased mechanization, there has been an increase in chemical use (pesticides and fertilizers) to produce greater crop yields.

Chemical fertilizers were used in excess between the 1940's and mid-1960's. By the late 1960's, it was realized that more was not necessarily better and that too much fertilizer could reduce crop yields. Farmers began to reduce amounts used, and by 1976 a balance had been reached (Parks, 1977). However, concerns remain about the amount of fertilizers used, and how runoff and seepage from agricultural land may affect the nutrient levels in surface and groundwater. A watershed study to monitor nutrients in samples taken from the Basin between April 1971 to June 1972 indicated that increased nutrient levels were found in ground and surface waters from areas of increased agricultural activity (New Brunswick Department of Agriculture and Montreal Engineering Company Ltd., op. cit.). It was also noted that in areas of increased agriculture there was an increase in population and other activities which could have had an effect on nutrient levels in the water supply.

In the amount of pesticide per acre used, potatoes rank third behind strawberries and apples. However, because of the large amount of farmland used for growing potatoes in the province, potato growers actually use more pesticide. The amount used will likely remain close to the present

level because in potato production, crops are not usually rotated and the nutrients need to be replaced each year. In New Brunswick between 1970 and 1975, the amount of fertilizer used on farmland ranged from 54,000 to 62,000 tonnes per year. Approximately 70 percent of this was used in the Basin counties of Madawaska, Victoria and Carleton which are the main potato-growing areas of the province (Parks, op. cit.).

The Water Quality Branch of Environment Canada, Moncton, regularly tests samples from the Basin for pesticides. Elevated levels were found particularly after intense rainfall (because of runoff) but were below acute lethal levels reported in the literature (New Brunswick Department of Agriculture and Montreal Engineering Company Ltd., op. cit). One of the more important environmental concerns associated with the use of some pesticides (particularly chlorinated hydrocarbons) is their persistence in the environment. In 1976, Eldrin and DDT and their breakdown products were found in sampling, even though Eldrin had not been used since 1972 and DDT had been banned before that (Parks, op. cit.).

In the past there have been agriculture pesticide-related fish kills. These resulted from overspraying, or overfilling of equipment, or incorrect disposal and cleanup of pesticide containers and spray equipment. However, farmer education has reduced these incidents to the point where they rarely occur (Wilson et al., 1980).

Large-scale livestock feed lot operations, henneries and piggeries began in the mid-1950's and with it came manure management problems. Before the introduction of relatively low-cost chemical fertilizers, manure was

used to increase soil fertility. With the animal waste all in one area, there was reduced incentive for the farmer to use it as a fertilizer (Parks, op. cit.). Unless the manure is properly used or treated, there is a concern that the soil will not be able to assimilate the nutrients and bacteria resulting in seepage to groundwater and runoff to streams, not to mention the odour problem.

Soil erosion in agriculture is always a concern as it will occur to some extent on farmed land with a slope greater than 3 percent (New Brunswick Department of Agriculture and Montreal Engineering Company Ltd., op. cit.). Farming occurs on steep slopes in the Grand Falls area, and erosion is a problem. Increased stone removal, increased farm size (where longer, continuous slopes are planted), decreased crop rotation (noted particularly when farming potatoes) have all increased the erosion problem (New Brunswick Department of Agriculture and Montreal Engineering Company Ltd., op. cit.). Bank erosion and flooding also contribute to the problem. Individuals have tried to stabilize banks on their property, but because of the dynamics of river systems, this usually results in more problems downstream. Erosion of agricultural land depletes the land of important topsoil and may result in increased sedimentation in streams.

2.1.3 Development of Commercial Fisheries

The commercial fishery in the Basin is located mainly in the Saint John estuary, with some smaller operations in the middle and upper basin (Meth 1973, 1974). Atlantic salmon (*Salmo salar*), American eel (*Anguilla rostrata*), gaspereau (*Alosa, pseudoharengus*), and shad (*Alosa sapidissima*) have traditionally represented the major catches of

commercial fishermen. These species, except American eel (which is catadromous[1]) are anadromous[1] and must migrate upriver to spawn.

The Atlantic salmon was once the most valuable fishery in the Saint John, but the fishery has declined in recent years because of reduced stocks and imposed quotas (Dadswell *et al*., in press). The decline coincided with the decline in the sports fishery in the 1950's and again in the late 1960's (see Table 2-4). The New Brunswick commercial salmon fishery was closed from 1971 to 1980. When the fishery opened in 1981, stringent quotas and restrictions were imposed. Landings have decreased since 1981 and the status of the fishery for next year is in question.

The American eel has become an important species for the commercial fishery. Between 1967 and 1971, landings increased to over 6,800 kg (Meth, 1974) and by 1983 average landings per year were 50,000 kg (Dadswell *et al*. *op*. *cit*.)(see Table 2-5).

The shad fishery was large in the past, but has declined during the last 20 years. From 1947, until Beechwood Dam was build, shad were fished in the middle basin, but this ended with the construction of the dam. The decline may also be partly due to the alteration of habitat caused by the construction of the Mactaquac Dam (Meth, *op*. *cit*.).

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[1]Catadromous fishes mature in freshwater and migrate seaward to spawn in salt water. Anadromous fishes reach sexual maturity in salt water and migrate to freshwater to spawn.

TABLE 2-4

TOTAL ATLANTIC SALMON LANDINGS FOR SAINT JOHN RIVER

Year	Sport Landings (number)	Commercial Landings ($kg \times 10^3$)
1951	1200	90
1955[1]	650	36
1960	800	64
1965	2500	100
1970[2]	125	36
1975	850	>3*
1980	1750	>3*
1981	425	41

Source: Dadswell, et al. in press (taken from Fig. 53)

Notes:
1 Spraying for spruce budworm began in 1953; Tobique Dam built in 1954; Beechwood Dam built in 1957
2 Mactaquac Dam built in 1967
* This catch represented incidental catch in other fisheries.
The Atlantic salmon commercial fishery in the Saint John River was closed between 1971 and 1980.

TABLE 2-5

EEL LANDINGS IN SAINT JOHN ESTUARY

Year	kg x 10^3
1962[1]	9
1965	7
1970	70
1975	52
1977	98
1980	23
1981	24

Source: Dadswell *et al*. 1983 (taken from Fig. 51)

Notes:
1 First year of any sizeable catch

Like the shad, gaspereau were fished in the middle basin until the Beechwood Dam was constructed. The fishery was largely located in Saint John harbour until 1965, and has since moved to the lake-like sections of the estuary (Dadswell *et al*., *op*. *cit*.). Between 1970 and 1971 gaspereau landings increased dramatically, and became the most valuable fishery in the estuary (Meth *op*. *cit*.). Landings in the fishery now average 2,000 MT/year (Dadswell, *et al*., *op*. *cit*.)(see Table 2-6).

TABLE 2-6

GASPEREAU LANDINGS IN SAINT JOHN ESTUARY AND HARBOUR

Year	$kg \times 10^6$
1947	1.3
1950	0.8
1955	0.9
1960	0.4
1965	2.8
1970	3.7
1971[1]	6.5
1975	1.8
1980	1.1
1982	0.8

Source: Dadswell *et al*. in press (taken from Fig. 52)

Note:
1 ban on commercial fishing for Atlantic salmon

2.1.4 Development of Tourism and Recreation

Tourism and recreation uses of the basin since World War II have provided both social and economic benefits. Jobs in the tourist industry represented 5% of the employed labour force in New Brunswick in 1981. Increased leisure time has allowed both residents and non-residents to enjoy the area. The following historical information was taken from "A Tourist Sector Strategy for New Brunswick" (Anonymous, 1982).

In the past twenty years the tourist trade has been variable. During the 1960's the number of people visiting the province increased by 10% a year. This increase slowed in the early 1970's and peaked in 1973 when more than 3.4 million tourists visited New Brunswick. Between 1974 and 1976 the number of visitors to New Brunswick declined and remained low until 1977. From 1977 to 1981 there was growth, and it is expected that this growth will continue. Table 2-7 gives tourist spending between 1971 and 1981. The figures given in 1978 dollars clearly illustrate the decline in the mid seventies and the gradual increase to 1981.

TABLE 2-7

Year	Tourist Spending $ Millions	Tourist Spending 1978 $ Millions
1971	111.4	200.1
1972	115.0	197.1
1973	125.0	199.9
1974	128.9	181.6
1975	140.0	173.7
1976	140.0	159.7
1977	170.0	181.1
1978	191.5	191.5
1979	225.0	202.0
1980	260.0	213.0
1981	290.0	214.0

Source: Anonymous, 1982

Another more recent trend observed is the shift to tourist travel during the off season. Traditionally the greatest tourist activity has been in July and August, where in 1971 67% of non-resident travel occurred at this time. In 1981, 54% of non-resident travel was during the summer, and an increase in activity during the fall was noted.

The basin is suited to various recreational activities, and is used by both resident and non-residents. New Brunswick residents are by far the more frequent users of recreational boating which includes yachting, sailing and power boating. In the basin, boating is concentrated in Kennebecasis Bay, Long Reach, Belleisle Bay, Washademoak Lake, Grand Lake and the Mactaquac headpond (Hustins, 1974). Canoeing is another popular recreational activity. There are a total of thirty canoeable waterways in the basin, with six rated as excellent, fourteen rated as good, and 10 rated as fair to marginal (Anonymous, 1970). Swimming activity in the province is located mainly on developed beaches with the majority of swimmers opting for inland tributaries and lakes rather than the main stem of the Saint John River (Hustins op. cit.). Other uses in the basin, called "appreciative recreation uses" by Hustins (op. cit.) include bird watching, photography, hiking, camping and site seeing.

Sports fishing occurs throughout the basin. The species most sought by the New Brunswick angler belong to the salmonid family, particularly brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*). Other sport fishes found in the basin include: landlocked Atlantic salmon, small mouth bass (*Micropterus dolomieui*), lake trout (*Salvelinus namaycush*), striped bass (*Morone saxatilis*),

white perch (*Morone americana*), yellow perch (*Perca flavescens*) and chain pickerel (*Esox niger*). These species are generally not as exploited as they could be, however, events such as bass fishing tournaments have helped spark interest. In 1975 the number of smallmouth bass angled was 34,228, in 1980 this increased to 160,902 (Hooper, 1979; 1983).

The brook trout is by far the principal sports fish in the basin. Between 1957 and 1966 the number of brook trout angled averaged 205,454 per year (A.P.W.R.S fish resources data - Saint John River, September 1967 as reported in Montreal Engineering Company Ltd., 1969). In recent years the number of fish angled has increased from 199,000 fish in 1970, to 1,228,264 fish in 1975 and to 1,810,860 in 1980 (Hooper, 1974; 1979; 1983).

The number of Atlantic salmon angled in the basin has varied from year to year. Between 1951 and 1966 the catch averaged 2604/year (Montreal Engineering Company Ltd., *ibid*.) There was a decline in numbers of fish caught in the 1950's during the time when forest spraying for spruce budworm was first initiated, and the Tobique and Beechwood Dams were constructed. In 1971 the population collapsed probably due to the negative impact of the Mactaquac Dam (Hooper and Ayer, 1984). Landings increased after this crash, likely due to the smolt production hatchery and fishway at Mactaquac, which helped mitigate the negative effects of the dam. These efforts, along with the federal ban on commercial salmon fisheries in New Brunswick rivers (from 1972 to 1981) helped to trigger the interest of the salmon anglers to the extent where angling effort for Atlantic salmon has increased by 78% between 1965 and 1983 (Hooper and Ayer *op*. *cit*.). In 1978 there was a sharp decline in the number of salmon angled. This was thought to result from

high mortalities from unknown causes on the high sea. In August, 1979, a policy was established whereby only grilse could be killed (Hooper, Dept. of Natural Resources, personal communication). The last peak in the salmon population was in 1980, when approximately 27,000 salmon were transported over Mactaquac (P. Cronin, Dept. of Natural Resources, personal communication). In 1983 the population crashed again and the "grilse only" regulation along with "hook and live release" for large salmon was reinstituted from the start of the 1984 salmon angling season. It is expected that this law will be in force again in 1985. Commercial fisheries for salmon were also curtailed in 1984.

2.2 Water Quality

2.2.1 Background Water Quality

The waters of the Saint John River have been described as being very soft with moderate to high colour and quite low alkalinity (Sprague, 1964 and Montreal Engineering Company Limited, 1969). Table 2-8 gives the range of values found by Sprague (*op. cit.*) in three surveys in 1959.

TABLE 2-8

BACKGROUND WATER QUALITY

	UNITS	RANGE
Colour	colour units	40 - 120
Hardness	mg/l	29 - 67
Alkalinity	mg/l	17 - 53
pH	pH units	70 - 8.0

While these values may be influenced by pollution in some reaches of the river, they probably give a good representation of background water quality. Other parameters such as dissolved oxygen and nutrient concentrations show a

far greater influence of pollution loadings. Heavy metals in the river are mainly determined by the bedrock geology of the basin. In many instances they may be higher than recommended standards. Table 2-9 compares typical values from Montreal Engineering Company Limited (1975) with Water Quality Guidelines for the protection of aquatic life.

TABLE 2-9

TYPICAL LEVELS FOR METALS

Parameter	Medium Level Found in Saint John River	Guideline
	(all values in mg/l)	
Cadmium	0.001	0.002
Copper	0.015	0.005
Lead	0.05	0.03
Zinc	0 to 0.03	0.03

Groundwaters in the basin are generally of good chemical quality although they are more mineralized than surface waters. (Montreal Engineering Company Ltd. op. cit.). Since the quality at any one place depends upon the bedrock geology at that place, differences in groundwater quality can occur.

High levels of iron and manganese occur in waters from various places throughout the basin. High chlorides are found in a few areas: near Edmundston in the upper basin, south of Fredericton and in the Sussex-Hampton area.

2.2.2 Changes in Surface Water Quality

Early water quality surveys on the Saint John River identified serious pollution problems. Sprague (1964) found low dissolved oxygen

conditions in the reach between Edmundston and Grand Falls with levels of 0.5 mg/L at St. Leonard and 1.7 mg/L in the Grand Falls headpond being recorded in August 1960, which was a period of drought and therefore very low flows. The Department of National Health and Welfare also surveyed the river in 1960 and found similarly low levels of dissolved oxygen with some of them occurring at average flow conditions. Depressed dissolved oxygen levels in the Beechwood headpond were also noted in both of these studies.

Sprague also noted that the influence of pulp and paper wastes, as measured by ammonia and nitrates, could be detected well downstream from Woodstock. The Department of National Health and Welfare survey also included coliform bacteria. There was at that time no sewage treatment in the basin above Oromocto and a zone of gross pollution was noted below each community.

The Maritime Provinces Water Resources Study (Montreal Engineering Company Limited) assembled data from water quality surveys up to 1968. The Saint John River Basin Board plan ing study updated this information to the early 1970's (Montreal Engineering Company Limited, 1975). Both of these studies reported similar results to the surveys undertaken 10 years earlier. Findings 1, 2, 4 and 7 of the latter study emphasize this point. They are reproduced below:

1) "The massive discharge of organic wastes at Edmundston has a marked effect on the water quality of the river for at least 175 miles downstream (i.e., to below Mactaquac Dam). These wastes account for approximately 80 per cent of the B.O.D. discharged into the main stem of the river above the tidal reaches of the estuary.

2) The most important long term concerns indicated by the data assessed are the deficiency of oxygen in the lower depths of the main stem headponds and the excess of nutrients being discharged into these water bodies.
4) The data available on fecal coliform levels indicate that acceptable limits for recreation and drinking are sometimes exceeded in the Basin and particularly in the upper reaches of the river.
7) The Aroostook, Presquile and Meduxnekeag Rivers have an important adverse effect on the water quality in the main stem of the Saint John River."

Since 1975 waste loads in the river have been drastically reduced. The single most important change was the conversion of the Fraser Companies Ltd. pulp mill at Edmundston which allowed recovery of pulping chemicals and effective treatment of the reduced pollution load.

Municipal waste treatment has proceeded to the point that only Edmundston and some areas of the City of Saint John discharge significant volumes of untreated sewage. Edmundston is presently in the process of installing waste treatment (Brian Barnes, personal communication, 1985).

With the installation of treatment systems at food processing plants in Maine, the waste loading to the Aroostook and Presque Isle rivers has been greatly reduced thereby reducing the loading on the Saint John River. A number of starch plants in New Brunswick have ceased operation thereby removing high BOD waste streams from the system.

In 1976, the International Technical Advisory Sub-Committee (ITAS) on water quality in the Saint John River was established. This sub-committee investigated the existing water quality in the international section of the Saint John River and compared those conditions to water

quality objectives (ITAS, 1979, 1980a, 1980b and 1983). In addition to this, Water Quality Branch (WQB) of Environment Canada has submitted several reports on water quality in the international section of the Saint John River to the sub-committee (WQB, 1983a, 1983b, 1984a, 1984b and 1984c).

Problem parameters and possible problem parameters have been identified (ITAS, 1979). Problem parameters include fecal coliforms, iron, manganese, phosphate and mercury (in the Madawaska River at Edmunston, the Saint John River at Ste. Basile and the Green River). Those parameters which have not been identified as problems, but which could be when more information is gathered include copper, mercury, pH, phosphate, dissolved oxygen and suspended solids. (ITAS op. cit.). ITAS (1980a) recommends safe level objectives (long term water quality management goal) and accute level objectives (an alert level which may indicate a potential problem) for these parameters.

Dissolved oxygen levels must be maintained for the protection of aquatic life. In 1980-81 data, no sample exceeded the acute level of 5 mg/L and all means were within the safe range for oxygen saturation (between 80% and 100%)(ITAS, 1983). However, between Trois Isles and Grand Falls less than 6.5 mg/L at 68-75% saturation was common. Oxygen depletion near Grand Falls was noted in other data reports (ITAS, 1980b, and WQB, 1984a). In September, 1983 oxygen concentration at Grand Falls was less than 5.0 mg/L (WQB, 1984a).

Fish species can tolerate a pH range from 5.0 to 9.5 for long duration. The pH of the Saint John is generally between 6.2 and 8.0, well

within the recommended level of 6.0 to 9.0 (WQB, 1984a), pH is also important because of its relation to the solubilities of gases, salts and metals.

Aluminum has a recommended safe level of 0.1 mg/L at pH 7.0 and greater (ITAS, 1980). In 1982-83 data, a high aluminum value was found. This was attributed to high sediment loading and it was suggested that all sites complied with the recommended levels (WQB *op. cit.*).

Increased phosphate can cause eutrophication of freshwater. Eutrophication yields increased numbers of noxious algae and may result in oxygen depletion. In 1980-81 phosphate levels were within the recommended safe levels (ITAS 1983), however in a more recent study WQB(1984a) reported three streams which were likely being eutrophied as a result of high phosphate levels.

Fecal coloforms objectives are set for drinking water and swimming. The recommended average level is 200/100 ml and with no sample with a concentration greater than 1000/100 ml. In the Saint John River an average of 630/100 ml for Clair and 900/100 ml for St. Basil exceeded the recommended level (WQB 1984c).

2.2.3 Changes in Groundwater Quality

The contamination of groundwater is usually a localized event and therefore does not receive the attention that a major point source of surface water does. Once contamination does occur, however, remedial measures are difficult and costly to put in place. Because a contaminated

aquifer may have its use impaired for many years, the cumulative effect of a number of events can be important.

Several sources of groundwater contamination have been noted including:

1) Petroleum spills and leaks from buried tanks.
2) Leachate from road salt storage.
3) Bacterial and nitrate contamination from manure storage.

Although there has been increasing concern with groundwater contamination in agricultural areas, the resource in general has maintained its "natural" level of water quality.

2.3 Industrial and Municipal Discharges

2.3.1 Industrial Discharges

Two trends have dominated the influence of industrial discharges on the waters of the Saint John River Basin since World War II. With the development of the forest products and food processing industries, industrial discharges had increased to the point where serious water quality problems occured. The second trend has been the recognition of these problems, resulting in a move to clean up industrial pollution problems through process modifications and waste treatment facilities.

The two main industrial sources at the beginning of the period covered by the present paper were a pulp and paper facility at Edmundston/Madawaska Me. consisting of a 400 ton/day (360 tonne/day)

sulphite pulp mill, an 85 ton/day (76 tonne/day) paper board mill and 135 ton/day (120 tonne/day) paper mill, and 200 ton/day (180 tonne/day) sulphite pulp mill at the mouth of the river at Saint John. Montreal Engineering Company Limited (1969) estimated an effluent loading of 302,000 lb/day (137,000 kg/day) BOD and 100,000 lb/day (45,000 kg/day) suspended solids from the Edmundston mills. The same report also estimated an industrial waste loading of 100,000 lb/day (45,000 kg/day) BOD from Madawaska Me. which was likely from the paper mill. In 1972, partial treatment (neutralization, followed by sedimentation and aeration ponds, for about one-third the effluent) was installed. The organic loading to the river was still estimated to be 100,000 kg/day (Montreal Engineering Company Limited, 1975). In 1979 the mill was converted to a bisulphate pulping process which allowed pulping liquor recovery and substantially reduced treated effluent loadings to those values shown in Table 2-10.

The Irving Pulp & Paper Limited mill at the mouth of the river in Saint John has been a major source of pollution to Saint John Harbour (as well as the immediate up-river environment due to the action of incoming tides). Montreal Engineering Company Limited, op. cit., cite N.B. Department of Fisheries and Environment data giving effluent discharges of 150,000 to 158,700 kg/day BOD and 41,000 to 45,350 kg/day suspended solids. A kraft mill was added and the sulphite mill was closed in 1977. With chemical recovery, the discharges to the river have been substantially reduced (see Table 2-7). In 1970, a 625 tonne/day bleached hardwood kraft mill was constructed at Nackawic by St. Anne-Nackawic Pulp & Paper Co. Ltd. Although this plant was sited on the Mactaquac headpond, a modern treatment system was installed at the time of mill construction and effluents have not produced water quality problems.

TABLE 2-10

INDUSTRIAL DISCHARGES TO SAINT JOHN RIVER - MAY 1984

	Waste Water Treatment Method	# BOD_5/day	#SS/day	Flow MGD
Nadeau Poultry	Solid & grease separator	709	381	0.21
Fraser Edmundston	Clarifier & aerated lagoon	36808	11741	23.99
McCain Foods, Grand Falls	Clarifier & packed tower biofilter	5044	1274	0.685
McCain Foods, Florenceville	Clarifier	15266	6620	2.10
Humpty-Dumpty, Hartland	Inplant treatment & aerated lagoons	10	0	0.03
Ste. Anne, Nackawic	Settling ponds & aerated lagoons	1650	8908	17.34
Irving Pulp & Paper	Inplant system	40975	13991	28.5

Source: Environment New Brunswick, 1984.

Next to the forest products industry, the largest industrial waste loads on the river come from the food processing industry. McCain Foods Ltd. opened a food processing plant at Florenceville in 1957 and one at Grand Falls in 1971. Up to 1969, untreated effluent was discharged to the river. Although they do not present effluent loading values, Department of National Health and Welfare (1960) comment on the waste as follows:

> "The river received the untreated process waste water from the factory. These waste waters were loaded with peas, stalks, pods and other coarse vegetable debris associated with this type of operation. Some of this waste settled quickly and putrified on the river bottom giving off offensive odours, while other parts floated for some distance and spread over a long stretch of the river before becomming waterlogged and eventually settling to the bottom to undergo further decomposition"

A primary treatment plant was installed at the Florenceville plant in 1969 with subsequent effluent loading being reported as 35,000 lb/day (16,000 kg/day) BOD and 6,400 lb/day (2,900 kg/day) suspended solids (Montreal Engineering Company, 1969). Similar BOD loadings but higher suspended solids loadings were found in the New Brunswick Water Authority Surveys of May 1971 and January 1972 as reported by The New Brunswick Department of Agriculture and Montreal Engineering Company Limited (1974). These authors reported that in-plant waste recovery systems had been installed since the New Brunswick Water Authority surveys. These included a system for removing mud and sprouts from potato fluming water, a starch recovery system and a fat skimming process. An estimate of the present effluent loadings from the Florenceville plant is given in Table 2-10.

The McCain Foods Ltd. Grand Falls processing plant has a modern waste treatment system (clarifier plus two trickling filters in series). At times this system has been overloaded resulting in high waste discharges. The estimated effluents for 1984 are given in Table 2-10. For various times throughout the period covered by this paper, starch plants have operated and produced high strength wastes. Montreal Engineering Company Limited (1969), for example, give an effluent loading of 10,900 lb/day (4,900 kg/day) BOD and 5,450 lb/day (2,500 kg/day) suspended solids for Pirie Potato Company and loading of 5,350 lb/day (2,400 kg/day) BOD and 5,950 lb/day (2,700 kg/day) suspended solids for Valley Co-op Limited. Both of these companies operated in Grand Falls but neither is in production at the present time.

Other food production facilities in the New Brunswick portion of the Basin include the Humpty-Dumpty potato chip plant at Hartland, the McCready's Foods Limited and Barbour Foods Limited complex at Sussex, as well as a number of dairies and meat packing plants. While some of these facilities nave caused local environmental problems, most have treatment systems or discharge to municipal systems and none have influenced water quality to the extent which pulp and paper mills or large food processing plants have.

In 1977 a neutral sulphite, semi-chemical pulp mill was constructed at Cabano, Quebec. From start-up this mill has had a modern efficient waste treatment system and has not caused downstream water quality problems.

Both the Aroostook and Presque Isle tributaries receive the effluent from a number of food processing plants in Maine. Montreal Engineering Company Limited (1975) give figures of organic pollutants as measured by TOC (Total Organic Carbon) in the Saint John River in 1972 of 457,000 kg/day immediately upstream of the confluence with the Aroostook and 627,000 kg/day immediately downstream. The Aroostook at that time contributed a major source of pollution to the main stem of the Saint John. While the Presque Isle river exhibited low dissolved oxygen levels and dense algae growths, the estimated loading on the Saint John was only 7.9 percent of the loading at Woodstock (Montreal Engineering Company Limited, op. cit.).

Since 1972, pollution abatement programs have eliminated much of this organic loading to the system. The International Saint John River Water Quality Committee (1984), for example, has estimated that organic loading (in terms of BOD) from point sources has been reduced by 88 percent between 1972 and 1982. They present a list of specific improvements including a number of industrial sources in Maine.

2.3.2 Municipal Discharges

Compared to industrial discharges, municipal effluents have had a minor and localized effect on water quality. Sewage contamination has however restricted recreational uses (swimming and boating) in some areas and untreated municipal effluents when added to industrial loadings have contributed to the gross pollution problems which the river has experienced. At present nearly all municipalities in the New Brunswick Portion of the Basin have satisfactory treatment systems (Environment New Brunswick, 1984).

Most of the sewage from the City of Edmundston does not presently have treatment, however, plans are underway to have a treatment system installed (Brian Barnes, Environment New Brunswick, personal communication, 1985). Saint John still discharges a portion of its sewage directly to the harbour.

2.4 Dams and Impoundments

2.4.1 Large Hydro-electric Dams

In the period covered by this paper, large dams (Beechwood and Mactaquac) were constructed on the main stem and the Tobique dam was built at the mouth of a major tributary. These dams have changed the character of the main stem of the river upstream of Fredericton from a fast-flowing river to a number of headponds, thus affecting its ability to assimilate waste. It has been estimated (Barnes, 1979) that 175 kilometres of the 265 kilometres between Edmundston and the Mactaquac dam comprises headponds.

The retention of polluted waters and the ensuing oxygen depletion and fish habitat degradation was one of the concerns of the Saint John River Basin Board Study. Experience had shown that the Grand Falls headpond had suffered severe water quality degradation and that problems extended downstream into the Beechwood headpond. Since Mactaquac was a larger headpond and was shown to have a more stable thermal stratification, concern was expressed that severe problems (e.g., oxygen depletion and algal blooms) would occur (Watt, 1973).

Although depressed oxygen levels have been measured below the thermocline, no serious algal blooms have been reported and the Mactaquac headpond continues to be a prime recreational area (boating, swimming and fishing).

Both the Mactaquac and Beechwood dams are equipped with fish passage facilities. At Mactaquac, the fish are collected and trucked around the dam. (Some are trucked as far as the Tobique River.) At Beechwood, there is a hoist to assist in fish passage. The hydro-electric dam at Tobique Narrows (at the mouth of the Tobique River) has a ladder-step fishway. Grand Falls has always provided a natural barrier to upstream fish migration. There are no fish passage facilities at Grand Falls at present. In order to compensate for losses in Atlantic salmon production upstream of Mactaquac, a hatchery was built in conjuunction with the Mactaquac dam. This facility was constructed by the New Brunswick Electric Power Commission and is an example of government industry co-operation to mitigate resource losses.

2.4.2 Small Dams

As was indicated in Section 1.3.3, there were 88 dams in the New Brunswick portion of the Saint John River system in 1969. Approximately half of these were built since 1946. Some of the older dams which were used as part of stream driving operations may no longer be in existence. New developments require approval as a water course alteration and therefore receive careful consideration for fish passage and fish habitat concerns.

3.0 THE ROLE OF INTERGOVERNMENTAL ACTION IN THE RESOLUTION OF WATER RESOURCE ISSUES

The resolution of water resource issues in a major river system is a complicated process extending over many years. The Saint John River provides an example of the many factors which have influenced the progress toward the restoration of the water resource. These include:

1. An identification of the problem and an understanding of its complexity. It is not sufficient to identify the sources of industrial pollution. The relative importance of discharges from outfalls and non-point source pollution should be understood as should the importance of impoundments in interacting with waste loading.

2. Public awareness of water resource problems and an assessment of public priorities. This is obviously helpful where the support of political leaders is necessary in taking action. It is also important that managers in other resource sectors appreciate the complexity of the water resource problem so that protection measures can be incorporated in their resource management decisions.

3. Mechanisms for influencing decisions on water resource issues from outside jurisdictions. In the case of the Saint John River, it was important to the clean-up efforts on both sides of the international border to show that progress was being made both in Canada and the United States.

4. Regulatory controls are an important factor in the clean-up of pollution problems. A strong regulatory position is necessary to negotiate meaningful compliance schedules. A recent court ruling against McCain Foods Limited did not result in large fines, however, it probably was a contributing factor in the company taking steps to provide waste treatment.

5. Provision of adequate financial support was a critical factor in reduction of municipal waste discharges to the river. Although industry might be expected to pay for its own pollution control, funds for modernization often allow an obsolete plant to be replaced and thereby provide substantial pollution control benefits.

3.1 Planning Studies

The Governments of Canada and the Province of New Brunswick have co-operated either informally or through formal agreements from the time of initial awareness and reaction to pollution control problems in the basin. The Maritime Water Resource Study, with joint federal and provincial funding, provided a comprehensive assessment of the water resource and identified development opportunities and some problems. In the Saint John River the disposal of industrial and municipal water was cited as a major problem.

By 1970 the Saint John River was being subjected to a number of pressures which threatened to further aggravate its water quality problems. In addition to the industrial pollution loads cited in the Maritime Water Resource Study, the Mactaquac dam had recently been constructed and others (Green River and Dickey Lincoln) were under consideration. It was known that these might affect the assimulative capacity of the river in a complex way, (i.e., water releases at low flows would assist in assimilating waste, however, headponds might trap pollutants and reduce natural re-aeration). Furthermore, forestry and agricultural practices were changing with a trend toward different land use practices (clear-cutting) and more use of pesticides.

It was with this background of uncertainty that the Saint John River Basin Board was established jointly by the governments of Canada and New Brunswick to undertake a comprehensive river basin planning study. An important aspect of the board's activities was a public participation program with field workers throughout the New Brunswick portion of the Basin.

The Saint John River Basin study was a high profile program extending over four years and involving the expenditure of $1,600,000. There were expectations that this effort would provide clear direction for the solution to the basins water management problems and provide an impetus for comprehensive water management. The fact that no implementation agreement was signed leaves the impression that the plan did not meet these expectations. In the absence of such a formal agreement by which implementation can be measured an analysis of the effectiveness of the Saint John River Basin Board efforts becomes subjective judgement. That being said, several observations can be made concerning the effect the Saint John River Basin study had on the restoration of the river.

Cardy (1983) has reviewed the Saint John River Basin Board Study and discussed some of the reasons for the lack of response to the plan. Most of these have also been mentioned in discussions with other resource managers.

> 1. Comprehensive planning study was not necessary to solve point source pollution problems. Industrial pollution was the most important water management issue.

2. The recommendations were presented in a complicated format which tended to diffuse their impact.

3. Many recommendations required the reassignment of responsibilities among government departments, as well as the creation of new agencies.

Many of the recommendations of the Saint John River Basin Board have been implemented. Two examples are an agreement between the governments of Canada and New Brunswick to undertake a flood damage reduction program and the establishment of a co-operative program to regulate alterations of water courses. The fact that the report identified the need for these programs and that the study provided a forum for water planners and managers to discuss common interests provided a basis for the development of these programs.

In the preparation and review of reports the Basin Board activity provided a mechanism for heightened awareness of water management problems for managers in all resource sectors in the region. This undoubtedly contributed to improved environmental practices in other resource sectors such as forestry and agriculture. In conclusion, despite a number of short comings the Basin Board study undoubtedly influenced progress toward the solution of water management problems in many positive ways.

3.2 Monitoring Programs

An important aspect of water resource management is on-going monitoring programs. Water quality monitoring programs provide a measure of

the success of pollution control programs as well as a warning system of key parameters whose build-up may lead to serious environmental problems. Monitoring programs related to river hydrology provide the basic data used for a wide range of management concerns including flood forecasting, the availability of electrical energy and the assimilation of pollutants.

The Inland Waters Directorate of Environment Canada has continuing programs to monitor both water quality and water quantity. Several water quality programs have extended back to 1965 (Belliveau and Lockerbie, 1981). These programs have emphasized major ions, nutrients and metals. Several special studies have also been undertaken to monitor the fate of pesticides, and other toic substances. The recent focus of federal water quality programs in the basin has been on international waters.

Federal water quality programs are complemented by those undertaken by Environment New Brunswick. The provincial program has concentrated on gathering baseline data on lakes and impoundments or providing baseline information where future developments may impact the water course (e.g., the development of potash mines on the Kennebecasis watershed).

A comprehensive federal stream gauging program began in New Brunswick in 1918. This program became a joint federal provincial program in 1974 and is continuing on that basis.

3.3 Regulatory Efforts

At present protection of the water resource is effected through a number of federal and provincial acts and regulations. The Saint John River Basin Board (1975) listed 25 federal acts and 39 Provincial acts relevant to water resource administration. The Water Quality Regulation under the Clean Environment Act provide the basis for provincial pollution control action. Each industrial facility is required to obtain a permit which specifies the conditions for discharge of a waste. The Fisheries Act (Subsection 33) provides the regulatory authority for the federal government to prevent the discharge of substances at levels harmful to fish. Levels of contaminants for each industry are specified under the act.

The lead agencies in regulating point sources pollution are the Pollution Control Branch of Environment New Brunswick and the Environmental Protection Service of Environment Canada. These agencies usually work co-operatively in negotiating regulatory controls with an industry. By informal agreement the province usually takes the lead in the negotiations but any course of action is approved by their federal counterparts to ensure that federal effluent standards are met. Both jurisdictions set effluent limits to limit the entry of pollutants to watercourses.

The various statutes provide a legal base for regulatory agencies to act. The use of court action is usually the last resort. Court actions which have been undertaken are listed in Tables 3-1 and 3-2. Although fines are usually small, the actions signify the serious intent of government regulatory actions as well as give adverse publicity to the company and often bring some progress toward pollution control.

TABLE 3-1

FEDERAL COURT ACTIONS FOR WATER POLLUTION RELATED CHARGES

DEFENDANT AND LOCATION	DETAILS OF CHARGE	DISPOSITION
Nadeau Poultry Farm St. Francois, N.B.	April 27, 1973 Discharge of poultry wastes.	Found guilty on July, 17, 1973, of violating Subsection 33(2). Fined $100.
Irving Pulp and Paper Ltd. Saint John, N. B.	From April 5 to 9, 1976, defendant allowed discharge of pulp with effluent (toxic wastes) into Saint John River.	On October 1, 1976, case dismissed.
Irving Pulp and Paper Ltd. Saint John, N. B.	On January 7, 1977, defendant allowed discharge of pulp with effluent (toxic wastes) into Saint John River.	Found guilty on April 16, 1977, of violating Subsection 33(2). Fined $3,500.00.
McCain Foods Limited Florenceville, N. B.	Between May 10-14, 1982, defendant allowed deposit of deleterious substance to the Saint John River, contrary to Subsection 33(2) and 33(5)(b) of the Fisheries Act.	Found guilty on all four counts February 27, 1984. Fined $1.00 for each count.
McCain Foods Limited Grand Falls, N. B.	Between May 17-21, 1982, defendant allowed deposit of deleterious substance to the Saint John River, contrary to Subsection 33(2) and 33(5)(b) of the Fisheries Act.	Found guilty on all four counts February 27, 1984. Fined $1.00 for each count.

TABLE 3-2

PROVINCIAL COURT ACTIONS FOR WATER POLLUTION RELATED CHARGES

DEFENDANT AND LOCATION	DETAILS OF CHARGE	DISPOSITION
McCain Foods Ltd.	Section 3(1) Clean Environment Act-Discharge of a contaminant.	Pleaded guilty. Fined $1,000.00.
Ronald Nadeau, Collin, Madawaska Co. N.B.	Section 3(1) Clean Environment Act-Discharge of a contaminant	Case dismissed. Revised copy of Certificate of Analysis not shown to defendant's counsel.
McCain Foods Ltd. Florenceville, N.B.	Section 3(1) of Reg. 82-126-Discharge of contaminant.	Pleaded guilty. Fined $3500.00
Ouellette and Freres St. Hilaire, N.B.	Section 3(2) of Reg. 82-126-Deposit of a contaminant upon the environment.	Found guilty. Fined $400.00.
Herve Hebert Saint Joseph, Mad. Co.	Section 11(2) of Reg. 82-126-Failure to report a discharge.	Found not guilty. "Acted in the spirit of the law although not to the letter".

The regulation of other actions which may degrade the water resource also involve co-operation between the two levels of government. Any proposed stream alterations are reviewed and approved by a committee comprised of representatives of Fisheries and Oceans Canada, Environment New Brunswick and the New Brunswick Department of Natural Resources. Environment New Brunswick regulates the sale and application of pesticides, while the chemicals themselves must be registered by Agriculture Canada.

The public usually becomes aware of regulating actions only when a court action takes place or the construction of a major pollution abatement facility is undertaken. What is not obvious is the continuing negotiations between regulatory agencies and industries or municipalities. These may extend over several years and involve many meetings and extensive monitoring programs. Regulatory actions themselves may involve a combination of methods including compliance schedules, control orders, the withholding of government financial assistance or court action. In addition to these regulatory efforts financial assistance is often provided to assist in plant modernizations or directly to construct waste treatment facilities. All of these instruments have been used to restore water quality in the Saint John River system to acceptable levels. Section 3.5 gives a brief outline of the efforts to bring several large industrial pollution facilities into compliance and provides examples of the use of the above strategies.

3.4 Financial Assistance

The provision of financial assistance by governments has made an important contribution to the restoration of the Saint John River. In New Brunswick municipalities receive grants from the province to finance capital projects. Many of these have been for sewage treatment facilities.

In the 1960's and 1970's joint federal provincial funding (40% federal/60% provincial) was provided to construct public water and sewer systems. Most municipalities have taken advantage of this funding and municipal waste discharges are no longer a serious problem (with the exception of the City of Edmundston which is in the process of installing treatment).

In 1965, the Canada Department of Fisheries and Forestry made available a pollution control fund to assist industries in eliminating organic pollution loading to the Saint John River upstream of the Mactaquac dam. Over three million dollars was made available for the construction of waste treatment facilities. The amount received by each industry was proportional to the amount of waste loading which was to be removed by the treatment system (as measured by Biochemical Oxygen Demand).

Three industries took advantage of this fund, Fraser Companies Ltd., McCain Foods Limited and Carleton Co-operative Ltd. A description of how the use of these funds assisted government regulatory action is given in the following section.

3.5 Progress in the Elimination of Major Sources of Industrial Pollution

3.5.1 Fraser Inc. Pulp Mill at Edmundston

Earlier sections of this report document that water quality survey in the 1960's clearly demonstrated the serious pollution problem posed by the discharge of untreated effluents from the Fraser Companies Limited (later Fraser Inc.) pulp and paper mill complex at Edmundston. Problems

with the excessive pollution loading (300,000 lbs./day) were aggravated by downstream impoundments which trapped pollutants and often exhibited severe water quality degradation.

Pollution control efforts were seriously constrained by the fact that the facility was an old mill of the type and size which made it impractical to continue operations and treat the liquid wastes to a desired level.

The first substantial progress in waste treatment was made about 1970 when the company took advantage of the Canada Department of Fisheries and Forestry's pollution control fund. Fraser built a waste treatment system capable of handling the effluent from a mill with chemical recovery in place and had to agree to rebuild the mill and install chemical recovery as soon as the financial position of the company would permit.

After a much larger corporation assumed ownership of the mill the rebuild took place and the mill then "matched" the treatment system. The treatment system is now operating effectively but is occasionally overloaded by upset conditions. Regulating efforts are now focused on pressuring the company to make in-plant improvements to eliminate spills and upset conditions.

3.5.2 Irving Pulp and Paper Ltd. Mill in Saint John

Another example of an old pulp mill which became a problem "inherited" by the new regulatory agencies in the 1970's is the Irving Pulp

and Paper Ltd. mill at the mouth of the river in Saint John. The facility consisted of a very old sulphite mill and a kraft mill. As was the case with the Fraser Inc. mill early negotiations produced very little in the way of progress in the reduction of waste loadings to the river.

In April 1976 and January 1977 charges were laid against the Irving Pulp and Paper Ltd. under the federal Fisheries Act. The first charge was dismissed but the defendant was found guilty in the second one and was fined $3500.

The important result of these court actions was the impasse between the regulatory agencies and the company was broken. Irving Pulp and Paper Ltd. undertook to close the sulphite mill and institute a pollution control program at the kraft mill. In this case the program was entirely funded by the company who chose to reduce discharges by in plant measures rather than by constructing an external treatment plant.

Although there are aesthetic problems with releases of foam to the Reversing Falls (a local tourist attraction) and Saint John harbour, the mill presently meets liquid effluent requirements of both the provincial and federal government. There remains a serious odor problem and regulatory efforts are being directed toward the reduction of air pollution.

3.5.3 St. Anne Nackawic Pulp and Paper Co. Ltd. Mill at Nackawic

The St. Anne Nackawic pulp mill is an example of the effectiveness of having a regulating system in place when a plant is constructed. A waste treatment system was constructed when the plant was built and the facility

has not caused serious water pollution problems. Even a "problem free" case such as this has required surveillance and on-going negotiations to ensure the waste management practices have kept up with changes in mill production and have made use of the best up-to-date technology. The New Brunswick Department of Fisheries and Environment was able to use the leverage of the provincial loan guarantees to require changes to the waste treatment system during one of the plant modernizations. The focus of regulatory concern with the St. Anne Nackawic Mill is presently odor problem from air emissions.

3.5.4 McCain Foods Limited Plants at East Florenceville and Grand Falls

Both the McCain Foods Limited plants on the Saint John River (East Florenceville and Grand Falls) have had waste management problems and are still the cause of regulatory concern. When initially constructed in 1957, the East Florenceville plant had no waste treatment facilities. Negotiations with the company were unsuccessful, until the money made available from the pollution control fund was used by the company to assist in the construction of a primary treatment plant. Subsequently a number of in plant changes were made to reduce pollution loadings and correct malfunctions in the treatment system.

A secondary treatment plant was not constructed and high pollution loadings to the river have continued. Negotiations with the company continued with pressure being applied to the company through the use of court actions and the withholding of part of the grants from the Department of Regional and Economic Expansion.

McCain Foods Limited pleaded guilty to two pollution related charges laid by the province (February 1982 and January 1984) and was found guilty on four counts of a charge laid by the federal government in February 1984. Although the fines have been small ($1000 and $3500 in the provincial case and $1.00 on each charge in the federal case), the actions appear to have had the desired effect since the company has hired a consultant to finalize the design for a secondary treatment system.

When the McCain Foods Limited plant at Grand Falls was constructed in 1971, an adequate waste treatment system was also built. The difficulty with the Grand Falls plant is that it has been expanded over the years without adequate expansion of the waste treatment facility. Federal and provincial regulatory agencies have not to date been able to resolve the situation although charges were successfully laid in February 1984 under the Fisheries Act (again with a $1.00 fine on each of four counts). Some of the money provided by the Department of Economic Expansion for plant expansion has been held back.

Until adequate waste treatment or waste reduction programs are put in place at East Florenceville and Grand Falls, effluents from these plants will probably continue to exceed federal and provincial standards, and require strong regulatory pressure.

3.6 Flood Damage Reduction

When a major flood occurs people look to government for emergency assistance during the event and later for compensation for damages incurred. Flood damages are also incurred directly by governments when government property or property into which the government has put funds is damaged. In

the 1973 flood of the Saint John River economic costs were estimated to be $10,780,000 with $6,630,000 being paid out by the federal and provincial government as compensation (Environment Canada, Inland Waters Directorate, 1974).

In 1976 the two governments signed an agreement to undertake a joint program aimed at reducing flood damages (see Appendix 1). While the program was province wide in scope, much of the emphasis was in the Saint John River Basin, particularly in the Fredericton area and the areas downriver of Fredericton to the Jemseg River. The agreement provided for three areas of action; flood forecasting, flood risk mapping and special studies.

A flood forecasting center was set up in Fredericton and provides river flow forecasts throughout the year. At times of spring freshet forecasting activity is stepped-up and water level information and one-day forecasts are provided to the local news media.

The flood forecasting effort requires extensive data collection of both the federal and provincial governments. Weather data as well as water levels throughout the Basin and snow and ice conditions are all used in preparing flood forecast information. Assistance has been obtained from the government of the United States through the Saint John River Basin Hydrology Committee (see Appendix 1).

The flood risk mapping program involves a detailed mapping of flood risk areas and a designation of flood prone areas. The designation provides for "floodways" where the governments will not provide financial

support for projects other than for recreational or agricultural purposes. In risk areas outside of "floodways" (termed the floodway fringe) support would be contingent upon flood proofing measures. Table 3-3 shows the areas of the basin which have been mapped and designated.

TABLE 3-3

FLOOD RISK MAPS

AREA	DESIGNATED WORKING MAPS			PUBLIC INFO. MAPS	
	NO.	SCALE	DESIGNATION DATE	NO.	SCALE
Fredericton	75	1:1000	Feb. 15, 1980	1	1:10,000
Lower Fredericton-Lincoln	14 18	1:1000 1:2000	Feb. 25, 1982	1	1:10,000
Oromocto-Lower Jemseg	8	1:10,000	Mar. 31, 1981	1	1:50,000
Perth-Andover	4	1:2000	Feb. 15, 1980	1	1:5,000
Sussex	14 21	1:2000 1:5000	Sept. 13, 1982	1	1:25,000
Keswick River	7	1:5000	Mar. 3, 1983	1	1:25,000
	161			6	

Source: Annual Report Steering Committee, Canada-New Brunswick Flood Damage Reduction Agreement for the Fiscal Year 1983-84.

Although no special studies have been carried out in the Basin, the March Creek area on the fringe of the Basin in the City of Saint John was the subject of a special study and a separate agreement whereby extensive capital works were undertaken to alleviate flooding.

The flood damage reduction program appears to be having the desired effect in that people are much more informed of water levels each spring, therefore, better prepared should a major flood occur.

4.0 PRESENT WATER MANAGEMENT CONSIDERATIONS AND FUTURE DIRECTIONS

4.1 Water Quality Issues

4.1.2 Water Quality Surveys

The focus of recent monitoring efforts has been on the international portion of the Saint John River. This work is now co-ordinated under the International Technical Advisor Sub-committee on Water Quality in the Saint John River Basin (see Appendix 1).

A recent report of this committee (International Technical Advisory Sub-Committee, 1983) indicates the substantial progress which has been made the quality of the Saint John River waters. Their data shows that for most parameters the water meet a "fishable-swimmable" objective. Parameters reported to meet these objectives were metals (arsenic, copper, lead and zinc), phosphorus, dissolved oxygen, ionized ammonia and suspended solids. The objective for aluminum was exceeded on two tributaries and both pH and temperature objectives were exceeded on one tributary.

The objective related to bacterial contamination was exceeded on the main river from the Madawaska River to 3 km below St. Basile as well as below St. Leonard and in the St. Francois River. Areas where this objective was exceeded would impair the use of the water for swimming.

While similar reports for the entire river are not available, it can be inferred that uses for most of the river are not impaired by water quality. Some areas still have problems with bacterial contamination and organic loadings may still be a problem immediately below industrial out

falls not in compliance with regulations (particularly in times of low flow).

4.1.3 Industrial and Municipal Pollution

When the sewage treatment plant at Edmundston becomes operative all the major municipalities on the river will have treatment in place. There remains a continuing effort to maintain and modernize the large investment in infrastructure which has been built up. Many of the sewage plants have reached the stage where replacements or modernization and required. Therefore adequate commitment to finance municipal waste treatment will be required if the progress attained to date is not to be lost.

The two McCain Foods Ltd. plants remain the outstanding problems in industrial pollution. If these plants were brought into compliance and all new industrial facilities on the river were to be constructed with adequate waste treatment systems, water quality should continue to improve.

4.1.4. Non-Point Source Pollution

As with point source pollutants much progress has been made in the elimination of land-use related pollutants to water courses. The regulation of pesticides includes testing for damage to aquatic systems. Through education and improved regulations the careless handling of pesticides (e.g., washing of spraying equipment in streams) appears to be much less prevalent.

Despite favourable trends the difficulty with non-point source or land use related pollutants is that their dispersed nature makes it

difficult to pinpoint the cause and effect of environmental problems. Many of these type of contaminants (e.g., mercury or polychlorinated biphenyls) must accumulate in the food chain before it is realized that a problem exists. This being the case it is difficult to predict where the next problem will arise or which of man's activities may be the cause.

Groundwaters are particularly vulnerable to contaminants by land use related pollutants. Because of the relatively slow movement of groundwaters the cause and effect could be separated by many years in time. Concern for the contamination of groundwaters in agricultural areas by nitrates and pesticides has, for example, initiated recent investigations by the New Brunswick Department of Health. The extent of this problem will be known when they report their findings.

4.2 Flooding and Erosion

As was indicated in the previous chapter, the most flood prone areas in the basin have been mapped and designated as flood risk areas. The flood forecasting program continues to provide information to alert people to the potential of damages from floods.

Erosion continues to be a problem, both from the point of view of loss of productive soils and the deposition of sediments in streams. The recent report of the Standing Senate Committee on Agriculture, Fisheries and Forestry (1984) estimates that 75 percent of land used for agriculture in New Brunswick needs some form of protection from erosion. Habitat loss due to erosion during forest harvesting operations is also of serious concern which requires attention.

4.3 Habitat Protection

Through the stream alteration permitting process a system is in place to regulate actions which might disrupt fish habitat. In practice, however, the success of the system requires a strong surveillance effort to ensure that changes to watercourses are actually completed according to the provisions of the permits. Better habitat mapping would assist the regulatory effort in establishing areas of priority.

The Canada Department of Fisheries and Oceans is currently reviewing its habitat management policy. This review will hopefully result in programs to gather more habitat information, as well as an increased field surveillance effort.

4.4 Recommendations for Future Measures to Improve Water Management Which Bear Upon Federal Responsibility and Control

Any recommendations for future directions in water management must be made with regard to the present situation. Substantial progress has been made and the trends of the early 1970's of deteriorating water quality have been reversed. Programs to prevent flood damage and protect fish habitat are in place. Rather than a dramatic shift in emphasis, the present situation calls for a consolidation and fine-tuning of the water management systems.

The greatest danger in the present situation is complacency. Faced with the need to reduce expenditures, governments may feel the job is done and withdraw from active participation in water management in the

basin. Without active government involvement at both the federal and provincial levels, it is likely that industrial treatment programs will not keep pace with process changes and municipal systems will not be maintained. The consequences would be a return to the conditions which prevailed fifteen years ago when uses of the river were in danger of becoming seriously impaired.

The following recommendations do not call for actions to combat a crisis situation. It is nonetheless important that the remaining problems be solved and the systems be maintained to ensure that the progress to date not be lost.

Pollution Control Considerations

1. An effective program to regulate industrial pollution must be maintained. The present system of co-operation between Environment New Brunswick and Environment Canada appears to be working well. There are indications that the last large industrial pollution source (the McCains East Florenceville Plant) may be reduced by the construction of a secondary treatment system. An ongoing regulatory effort is required to ensure pollution control efforts keep up with plant expansions and that new facilities are build with adequate waste treatment. The federal role in surveillance, research, and where necessary, legal action is required to support the provincial effort to protect the aquatic system.

2. The investment in infrastructure to collect and treat municipal sewage must be protected. The present level of funding, which comes entirely from the province is not adequate to maintain the systems and ensure their modernization. It is, therefore, recommended that the federal government and province undertake to jointly provide a level of funding so that the progress gained in municipal waste treatment will not be lost.

3. The problem of combatting non-point source pollution requires a varied approach. More research is needed on the effects of land use practices in forestry and agriculture on the water resource. The use and disposal of hazardous materials clearly require a continuing effort.

The deposit of airborne pollutants including anions which contribute to acidity must be monitored and research on cause and effect relationships continued.

Monitoring

4. The monitoring efforts on the international section of the Saint John River should be brought under the terms of reference of the International Joint Commission, so that a mechanism exists for formally implementing an agreed upon action.

5. Monitoring programs in the rest of the basin (outside international waters) should be maintained, or reinstated where special situations require. Two areas for which more water quality information would be useful are the Mactaquac headpond and the lower estuary. Both areas could act as indicators of the long term "health" of the basin's aquatic system.

Habitat Protection

6. An increased effort in fish habitat protection is required. The required actions include habitat mapping, research into cause and effect (e.g., of forestry operations on habitat) and mitigative measures and an increased surveillance effort.

Flood Control Issues

7. People should continue to be made aware of potential problems of development on flood planes. Flood forecasting is an effective tool of public awareness. Other information programs should be supported by both federal and provincial governments.

5.0 REFERENCES

Anonymous. 1970. New Brunswick canoeable waterways study. Research and Planning Branch, New Brunswick Department of Tourism.

Anonymous. 1982. A tourist sector strategy for New Brunswick, New Brunswick Department of Tourism.

Barnes, B.B. 1979. International co-operative activities in the Saint John River Basin. Canadian Water Resources Journal,4(3), 92-101.

Belliveau, P.E. and D.M. Lockerbie. 1981. Water Quality Branch activities in New Brunswick 1965-1980. IWD-AR-WQB-81-11 Water Quality Branch, Inland Waters Directorate, Environment Canada, Atlantic Region.

Bruley, A.J. 1974. Training Manual on the basic technology of the pulp and paper industry and its waste reduction practices. EPS 6-WD-74-3 Water Pollution Control Directorate, Environment Canada.

Cardy, W.F.G. 1983. River basins and water management in New Brunswick. In: River basin management: Canadian experience. Edited by B. Mitchell and J. S. Gardner. Faculty of Environmental Studies, Department of Geography, University of Waterloo, Ontario. Publication Series No. 20. pp. 61-70.

Dadswell, M.J., R. Bradford, A.N. Leim, G.D. Melvin, R.G. Appy and D.J. Scarratt. A review of fish and fisheries research in the Bay of Fundy between 1976 and 1983. In: An update on marine environmental consequences of tidal power development in the upper reaches of the Bay of Fundy. Edited by D.C. Gordon Jr. and M.J. Dadswell. Can. Tech. Rep. Fish. Aquat. Sci. (in press).

Department of National Health and Welfare Canada. 1961. Survey report: effects of pollution-Saint John River, New Brunswick and Maine. Public Health Engineering Division.

Englert, J., J.W.A. Grant and B.F. Bietz. 1982. Impact of logging and associated practices on salmonid standing crop in the Maritimes. Atlantic Region Environmental Protection Service, Environment Canada Surveillance Report EPS-5-AR-82-4.

Environment Canada. 1974. The New Brunswick flood April-May 1973. Technical Bulletin No. 81, Inland Waters Directorate.

Environment New Brunswick. 1984. Summary of operating conditions of wastewater treatment plants. Prepared by Pollution Control Branch, Department of the Environment. Province of New Brunswick Report T-8403.

Hartman, G.F., J.C. Scrivener, M.J. Brownlee, and D.C. Morrison. 1983. Fish habitat protection and planning for forest harvesting in coastal streams of B.C.; some research and management implications. Can. Ind. Rep. Fish Aquat. Sci. 143.

Hooper, W.C. 1974. The New Brunswick Atlantic salmon sport fishery 1969-1973. Fisheries Management Report No. 4. Fish and Wildlife Branch, Department of Natural Resources, New Brunswick.

Hooper, W.C. 1978. The New Brunswick Atlantic salmon sport fishery, 1972-1977. Fisheries Management Report No. 7. Fish and Wildlife Branch, Dept. of Natural Resources, New Brunswick.

Hooper, W.C. 1979. The 1975 New Brunswick sport fishery. Fisheries Management Report No. 9. Fish and Wildlife Branch Dept. Natural Resources, New Brunswick.

Hooper, W.C. and C. Ayer. 1984. Re-allocation of sea-run Atlantic salmon and potential of landlocked salmon in Canadian sport fisheries. Paper given at the 1984 Canadian sport fisheries conference, Vancouver, B.C. February, 1984.

Hustins, D.G. 1974. Tourism and outdoor recreation in the Saint John River Basin. A report prepared for the Saint John River Basin Board. Report No. 10.

Inland Waters Directorate. 1973. Hydrology of the Saint John River Basin. A report prepared for the Saint John River Basin Board. Report No. 2. Department of the Environment.

International Saint John Water Quality Committee. 1984. 12 years of progress. International Saint John Water Quality Committee 1972 - 1984.

International Technical Advisory Sub-committee, 1979. Water quality data analysis and sampling program for the international water of the Saint John River Basin. Report of the Water Quality and Sampling Sub-committee to the Canada-United States Committee on water quality in the Saint John River. January 1979. 39p plus figures and tables.

International Technical Advisory Sub-committee. 1980a. Review and update of water quality objectives for the international waters of the Saint John River Basin. ITAS report on water quality in the Saint John River. September, 1980. 51 p. plus appendices.

International Technical Advisory Sub-committee. 1980b. Interpretation of 1979/80 surveillance data for the international waters of the Saint River Basin. ITAS report on water quality in the Saint John River Basin. October, 1980. 27p.

International Technical Advisory Sub-committee. 1983. Interpretation of 1980/81 surveillance data for the international waters of the Saint John River Basin. ITAS report on water quality in the Saint John River Basin. February, 1983. 35p. plus figures.

MacNeill, J.W. 1971. Environmental management. A study prepared for the Privy Council office, Government of Canada.

Meth, F.F. 1973. Sports and commercial fisheries of the upper and middle Saint John River. A report prepared for the Saint John River Basin Board. Report No. 7d.

Meth, F.F. 1974. Sport and commercial fishery of the Saint John estuary. A report prepared for the Saint John River Basin Board. Report No. 7b.

Montreal Engineering Company Limited. 1969. Maritimes water resource study, stage 1. Vol. 3, New Brunswick: book 3. A report prepared for the Atlantic Development Board.

Montreal Engineering Company Limited. 1975. Water quality in the Saint John River Basin. A report prepared for the Saint John River Basin Board. Report No. 4.

New Brunswick Department of Agriculture and Montreal Engineering Company Limited. 1974. Agriculture and water management in the Saint John River Basin. A report prepared for the Saint John River Basin Board. Report No. 5.

Parks, A.C. 1977. Report of the agriculture resources study. Prepared for the Province of New Brunswick, Fredericton.

Powell, G.R. (ed.) 1983. Nashwaak experimental watershed project, annual report, 1981-82. A cooperative study of the environmental impacts of forestry practices. Published by Nashwaak Experimental Watershed Project Technical Committee of the New Brunswick Forest Research Advisory Committee.

Saint John River Basin Board. 1975. Water resources and water use. In: A plan for water management in the Saint John River Basin, Pt 1. Final report of the Saint John River Basin Board.

Sigvaldason, O.T. 1975. Electric power and water management in the Saint John River Basin. A report prepared for the Saint John River Basin Board. Report No. 14.

Standing Senate Committee on Agriculture, Fisheries and Forestry. 1984. Soil at risk. Canada's eroding future. Report on soil conservation by the Standing Committee on Agriculture, Fisheries and Forestry to the Senate of Canada. Hon. H.O. Sparrow, Chairman.

Water Quality Branch. 1983a. Report on the 1982 Saint John River automatic water quality monitor data at Grand Falls, N.B. Inland Waters Directorate, Environment Canada. Report IWD-AR-WQB-83-47, 13 p plus figures and appendix.

Water Quality Branch. 1983b. International Saint John River fecal coliform survey, August, 1982. Inland Waters Directorate, Environment Canada, Report IWD-AR-WQB-83-38. 17 p. plus appendix.

Water Quality Branch. 1984a. Compliance of selected water quality parameters to the objectives of the international waters of the Saint John River Basin during the years 1982 and 1983. Inland Waters Directorate, Environment Canada. Report IWD-AR-WQB-84-56. 30 p.

Water Quality Branch. 1984b. Report on the 1983 Saint John River automatic water quality monitor data at Grand Falls, N.B. Inland Waters Directorate, Environment Canada. Report IWD-AR-WQB-84-66. 18 p. plus appendix.

Water Quality Branch. 1984c. International Saint John River bacteriological survey, July, 1983. Inland Waters Directorate, Environment Canada. Report IWD-AR-WQB-84-70. 21 p. plus appendix.

Watson, R.S. 1983. New Brunswick forest industry and forest resources, an overview. A background paper prepared for the N.B. Private Woodlot Resources Study.

Watt, W.D. 1973. Aquatic ecology of the Saint John River. Volume I. Background, design, methods, nutrients, bacteria, phytoplankton and primary production. A report prepared for the Saint John River Basin Board.

Welsh, H.E., P.E.K. Symons, and D.W. Narver. 1977. Some effects of potato farms and forest clearcutting on small New Brunswick streams. Fish. Mar. Serv. Tech. Rep. 745.

Wilson, R.C.H., P.B. Eaton, S.E. Hall and H.H. Stone. 1980. Environmental quality in the Atlantic Provinces: 1979. Environment Protection Service, Environment Canada, Halifax, N.S.

APPENDIX 1

INTERGOVERNMENTAL COMMITTEES RELATING TO THE SAINT JOHN RIVER BASIN

A.1 The Atlantic Provinces Water Resource Study

The Atlantic Development Board commissioned two studies in 1967: a study of the administration of water resources in the Atlantic Provinces and a study of the water resources in the Maritime Provinces. The terms of reference for the study of the administration of water resources called for a comprehensive description of the administrative structure, function and decision-making process for the planning, organization and management of the water resources in each of the Atlantic provinces. It also called for an identification of the implications for administration of future investment in water resource development programs.

When the study was completed, a series of recommendations were put forward, eight of which applied specifically to New Brunswick and were directed at the New Brunswick Water Authority. The first recommendation is particularly relevant to subsequent developments in the Saint John River Basin in that it called for the preparation of a comprehensive plan for water resource development in the basin.

The Maritime Provinces Water Resource Study analysed water supply and demand and identified problems, possibilities and priorities for the Maritime provinces. The study looked at river basins as well as selected study areas in each of the three provinces. Coverage of the Saint John

River Basin included a section on the Basin as well as special studies of Edmundston, Fredericton and Saint John.

Pollution from untreated or inadequately-treated industrial and municipal wastes was identified as the most serious problem in the Basin. Serious problems were identified as resulting from the disposal of pulp and paper mill wastes at Edmundston, food processing wastes at East Florenceville and from tributaries entering New Brunswick from Maine. Potential problems with the eutrophication of the Mactaquac headpond were also noted. Other problems identified included: sunken wood at Oromocto, industrial and municipal pollution of Saint John Harbour, erosion of farmland and the flooding of farmland below Fredericton.

A.2 The Saint John River Basin Board

The Saint John River Basin Board was established jointly by the governments of Canada and New Brunswick on June 30, 1970 as a comprehensive river basin planning study. The agreement, which pre-dated the Canada Water Act by a few months, did not extend to implementation. No implementation agreement was signed (as was the case with the Qu'Appelle and Okanagan studies).

The objective of the study was:

> "to provide for optimum management of the water resources of the river basin for the social betterment and economic improvement of the region with due consideration to the maintenance of a proper ecological balance" (Saint John River Basin Board, 1975).

A planning office and a public participation program were established. These functions reported to a board of three appointees by the Government of Canada and three appointees by the Province of New Brunswick. An advisory committee was appointed to facilitate liaison with interested federal and provincial government departments.

The board completed its work in 1975 and reported to the two governments. The plan was formulated in terms of a comprehensive framework for management which presented various levels of decisions, tasks, policies, and responsibilities. One hundred and fifteen recommendations were directed at water-users and water-resource managers. In addition to the plan, 16 resource or sector reports were published.

A.3 International Saint John Water Quality Committee

The International Saint John River Water Quality Committee was formed in 1972 under an agreement between the governments of Canada and the United States. The International Joint Commission was designated to oversee its operation. The goals of the committee, which were set when the committee was established, are:

1. Demonstrate ways in which countries could cooperate in reducing water pollution to their mutual benefit.
2. Develop improved techniques and concepts for water quality management.

3. Review periodically progress in the conduct of water quality planning on both sides of the Canada-United States boundary in the Saint John River Basin, with a view to facilitating progress toward enhancement of water quality.
4. Exchange appropriate information about plans, programs, and actions which could affect water quality in the Basin.
5. Assist in coordination and consultation amoung appropriate authorities on matters and actions affecting water quality.
6. Make appropiate recommendations to relevant authorities on both sides of the boundary and to the International Joint Commission regarding the improvement of water quality in the Basin.

The International Saint John River Water Quality Committee which consists of three members from Canada, three members from the United States and a secretary meets on a regular basis to exchange imformation and review programs. An International Technical Advisory Subcommittee carries out tasks as directed by the Committee. The sub-committee regularly publishes the results of water quality surveys on the river. An earlier publication reviewed some of the pollution problems studied by the committee and presented specific set of water quality objectives for the international waters of the Saint John River.

A.4 Saint John River Basin Hydrology Committee

This committee was formed in 1979 by an exchange of letters between various Canadian and United States government agencies. It was formed to ensure the continuation of the exchange of information and co-operation which had existed during the pilot project on the application of World Weather Watch to operational hydrology. The committee, whose members represent federal government agencies in Canada and the United States as well as agencies from the provinces of New Brunswick and Quebec, meets twice a year to exchange information and to discuss means of co-operating on programs of common interest. The co-operation on measurement of snow packs in the upper basin has been particularly useful to the flood forecasting effort in the basin.

A.5 Canada-New Brunswick Flood Damage Reduction Steering Committee

This committee was constituted under the Canada-New Brunswick General Agreement Respecting Flood Damage Reduction which was signed on March 31, 1976. The original agreement was for a ten-year period however it was amended on July 16, 1981 to extend the term for an additional five years. While this agreement covers the whole province, most of the effort has been placed on the Saint John River Basin where the most serious flooding problems have occurred.

The steering has two members from the Government of Canada and two from the Province of New Brunswick. Technical committees with representatives of both governments also exist for the flood risk mapping program, the flood forecasting program and for any current flood damage reduction studies.

The agreement provides for sub-agreements on flood risk mapping, flood forecasting and special studies. Flood risk maps have been completed for Fredericton, Lower Fredericton-Lincoln, Oromocto-Lower Jemseg, Perth-Andover, Sussex and the Keswick River areas. These areas have all been designated as flood risk areas so that no federal nor provincial funds will be made available for developments unless flood-proofing takes place.

A flood forecast for the Saint John River was established in June 1978, and has operated since that time. During the period of spring freshet the forecast centre commences daily operation and provides water level information and one-day forecasts to local media outlets. During periods of high water, three-day forecasts are also provided.

No special studies have been carried out within the Basin. A study of Marsh Creek in Saint John (technically outside the Basin but adjacent to it) led to a separate sub-agreement to construct flood protection measures.

APPENDIX 2

TERMS OF REFERENCE

The objectives of the assignment are:

To review stresses on the water environment created during postwar economic development of the Saint John Basin; and to assess progress of and remaining needs for intergovernmental co-operation in restoring a satisfactory balance among water uses.

The tasks included in this assignment are:

1. Review post-World War II developments in the Saint John Basin, with emphasis on forestry, agriculture, energy projects, resource-processing industry and growth of urban communities and their impacts on the basin's water resources, e.g. flow control, erosion and sedimentation, waste discharges, flooding, aquatic habitats;

2. Describe the major intergovernmental programs which have focussed on Saint John waters and water use issues over the past two decades, including those of the Atlantic Development Board, Saint John River Basin Board, International Saint John Water Quality Committee, Saint John River Basin Hydrology Committee, and Canada-New Brunswick Flood Damage Reduction Steering Committee, and assess generally what has been achieved and what issues remain outstanding;

3. Assess in particular the progress of clean-up resulting from government-industry negotiations, court actions and (community) assistance programs throughout the Canadian portion of the basin, not minimizing remaining difficulties, e.g., the recent case of $8 fine for conviction on 8 counts of pollution;

4. Recommend measures for improving water management or accelerating remedial programs in the Saint John Basin which bear upon federal responsibility and performance.

Inquiry on Federal Water Policy

Enquête sur la politique fédérale relative aux eaux

Research Papers

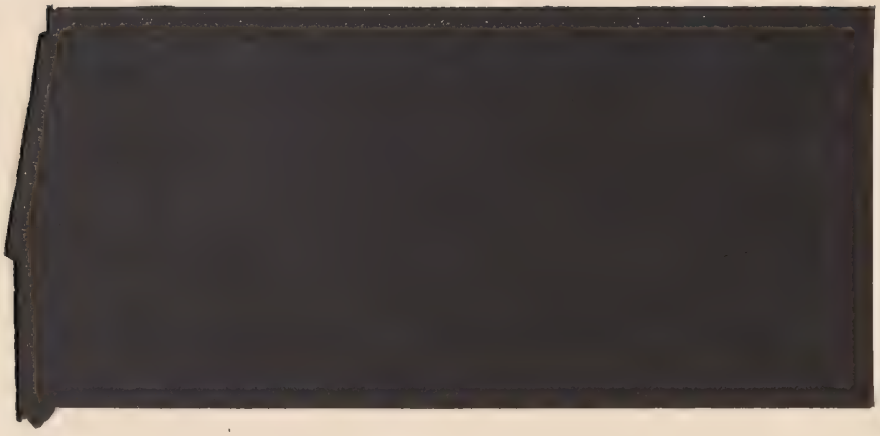
Documents de recherche

GROUNDWATER ISSUES: AN OVERVIEW

by

J.A. Vonhof

Canada



Inquiry on Federal Water Policy
Research Paper #14

GROUNDWATER ISSUES: AN OVERVIEW

by

J.A. Vonhof

Vonhof Consulting Limited
Calgary

May 1985

THE INQUIRY ON FEDERAL WATER POLICY

The Inquiry on Federal Water Policy was appointed by the federal Minister of the Environment in January of 1984 under the authority of the Canada Water Act. The members were Peter H. Pearse, chairman; Françoise Bertrand, member; and James W. MacLaren, member. The Inquiry was required by its terms of reference to review matters of water policy and management within federal jurisdiction and to make recommendations.

This document is one of a series of research papers commissioned by the Inquiry to advance its investigation. The views and conclusions expressed in the research papers are those of the authors. Copies of research papers and information on the series may be obtained by writing to the Enquiry Centre, Environment Canada, Ottawa, Ontario K1A 0H3.

Frank Quinn

Frank Quinn
Director of Research

Abstract

Groundwater is a neglected resource in Canada. Although approximately 30 percent of the population depends on groundwater, the diffuse distribution of users, primarily the rural population, has resulted in relatively little attention on groundwater development and protection by government agencies.

Although it has long been recognized that surface water and groundwater are components of an interactive system, the effects of surface water development on groundwater flow systems is generally neglected, as is the effect of induced changes in groundwater systems on downstream users of the total water resource.

The attention paid by the province to the protection of groundwater resources is a function of their relevance as a source of potable water. Because of the inevitable time delay between the introduction of a contaminant into a groundwater flow system and its re-entry into another part of the terrestrial environment, groundwater contamination is generally not regarded as a politically urgent problem.

Groundwater contamination problems in various parts of the country are in many instances unique and determined by the industrial activity and resource base. It is not possible at this time to accurately assess the extent and severity of groundwater contamination because there is no readily available data base.

In order to protect groundwater resources, and indirectly the quality of surface water resources, for the future, it is suggested that the federal government assume a much more active role. The protection of this resource is in the national interest and should as such be defined in a federal policy. The protection strategy developed by the Environmental Protection Agency in the United States could serve as a model for policy planning by the Canadian government.

Résumé

Les eaux souterraines sont une ressource négligée au Canada. Bien qu'environ 30% de la population utilise les eaux souterraines, la dispersion de ces utilisateurs, majoritairement des utilisateurs ruraux, explique le fait que peu d'attention ait été accordé à la protection et au développement de cette ressource.

Bien qu'il soit depuis longtemps reconnu que les eaux de surface et souterraines sont des composantes d'un même système, les effects du développement des eaux de surface sur l'écoulement des eaux souterraines sont généralement négligés; il en est de même des effets provoqués par un changement dans le réseau des eaux souterraines sur les utilisateurs de la ressource eau en aval de ces changements.

L'attention apportée par les provinces à la protection des eaux souterraines est fonction de leur utilisation comme source d'eau potable. Parce qu'il y a

un délai inévitable entre l'introduction d'un contaminant dans les eaux souterraines et sa réapparition ailleurs dans l'environnement terrestre, la contamination des eaux souterraines n'est généralement pas reconnue comme un problème politique urgent.

Les problèmes de contamination des eaux souterraines sont souvent uniques à chacune des régions du pays et déterminés par l'activité industrielle et les ressources présentes. Il n'est pas possible actuellement d'évaluer de façon précise l'étendue et la sévérité de la contamination des eaux souterraines parce qu'il n'y a pas de base de donnée facilement accessible.

Afin de protéger les ressources en eaux souterraines et indirectement la qualité des eaux de surface, il est suggéré que le gouvernmement fédéral assume un rôle beaucoup plus actif. La protection de cette ressource est d'intérêt national et devrait donc être l'object d'une politique fédérale en la matière. La stratégie de protection développée par l'Agence de protection de l'environnement (EPA) des États-Unis pourrait servir de modèle de planification pour le gouvernement fédéral.

Groundwater Issues: An Overview

Objective

To assess the quantitative and qualitative stresses on Canadian groundwaters, and opportunities for greater conjunctive management with surfaace waters.

Tasks

1. Describe briefly groundwater properties and behaviour within the hydrologic cycle (introductory);

2. Assess problems of groundwater overdraft and their consequences (e.g. subsidence, salt-water intrusion, reduced contribution to streamflow); and opportunities for alleviating water shortages by induced recharge of aquifers and conjunctive use;

3. Assess the severity of groundwater contamination from various industrial, municipal and agricultural sources, and progress in controlling these sources; consider the long term effects of waste disposal practices;

4. Recommend measures by which the federal government can contribute appropriately to improved groundwater management, through data, research and/or other interjurisdictional programs.

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I. GROUNDWATER AND THE HYDROLOGIC CYCLE

1.1 Introduction

It is estimated that the earth contains approximately 1.36×10^9 km^3 of water, 97.5 percent or 1.33×10^9 km^3 of which is salt water. Of the remaining 2.5 percent, which makes up the world's total freshwater supply, 87.3 percent or 3.33×10^7 km^3 is frozen in the polar ice caps and in glaciers in various parts of the world, 12.3 percent or 4.1×10^6 km^3 is groundwater and of the final 0.4 percent or 1.34×10^5 km^3 some is stored in lakes and rivers and some is present in the atmosphere (Morris, 1969). Figure 1 summarizes the distribution of the water resources of the earth. It is obvious from figure 1 that groundwater constitutes the largest accessible source of freshwater.

The world's freshwater supply is maintained by a gigantic natural distillation and circulation system, i.e. the hydrologic cycle. Water evaporates from the earth's surface (oceans and land), condenses to form clouds, and is returned to the earth as precipitation (Fig. 2). The moisture which falls over land as precipitation may follow a number of different paths before it is returned to the atmosphere. Part of the precipitation evaporates while falling. Some of the precipitation that reaches the land surface quickly returns to the atmosphere through evaporation. A portion of the precipitation will result in runoff, which collects in streams or rivers and is subsequently transported toward lakes, seas and oceans. During its travel part of it will evaporate and the portion that reaches the final

destination will eventually be returned to the atmosphere by evaporation. Another part of precipitation will infiltrate into the ground. Upon infiltration it replaces the soil-moisture deficiency. Part of this water is lost to the atmosphere by upward capillary transport and subsequent evaporation, whereas another part is taken up by vegetation and a portion of this water is released to the atmosphere by transpiration. If the soil reaches a specific degree of saturation, infiltrating precipitation can reach the watertable, where it becomes part of the groundwater flow system.

Although the hydrologic cycle is simple in concept, the analysis of its components is an extremely complicated task due to the many alternative routes water may follow in every phase of the cycle and the different climatic, geological, and biological environments through which it moves. In this paper only one portion of the hydrologic cycle will be discussed, namely groundwater flow and the related topic of groundwater pollution. It is not the objective of this paper to discuss in detail the theory of groundwater flow or the chemical evolution of groundwater. Only those aspects which are considered relevant to the discussion are touched upon. For a complete review of groundwater flow the reader is referred to Freeze and Cherry (1979).

1.2 Groundwater Flow

In order to understand the occurrence and movement of groundwater and consequently the movement of pollutants, it is necessary to describe a few fundamentals of groundwater flow.

According to Hubbert (1940), groundwater flow takes place from regions with high fluid potential to regions with lower fluid potential, regardless of the direction of flow in space. The fluid potential is equal to the mechanical energy per unit mass of fluid. For flow through a porous medium where the flow velocities are extremely low and the liquid is isotropic and incompressible, it can be shown that the fluid potential is equal to the hydraulic head multiplied by the acceleration due to gravity. Since acceleration due to gravity is very nearly constant in the vicinity of the earth's surface, and certainly within finite study areas, the fluid potential is proportional to the hydraulic head. It can further be shown that the hydraulic head at a point in a groundwater flow system, if the reference datum used is mean sea level, is the elevation of the free water surface in a piezometer completed at that point. If the hydraulic head distribution of an area is considered under idealized conditions, i.e. homogeneous and isotropic, then the areas with higher fluid potential correspond to the topographically high regions, and areas with lower fluid potential occur in the topographically low regions. This is illustrated in Figure 3. By definition, that portion of the topographically high area in which the net saturated flow is directed downward, away from the watertable, is called a recharge area, whereas in a discharge area the net saturated flow is directed upward, toward the watertable. The effect of topography on the groundwater flow system has been discussed at length by Tóth (1963) and by Freeze and Witherspoon (1967). Both authors show that topography alone can create complex systems of groundwater flow.

Thus far groundwater flow patterns have been discussed in terms of idealized

environments, i.e. uniform permeability distribution. However, the permeability distribution of the natural environment is anything but uniform and is characterized by considerable variation in both a vertical and a lateral sense. Since the magnitude of the permeability of sediments is inherent to the type of sediment, and the distribution of a particular sediment is determined by the depositional environment, a first approximation of the permeability distribution in space can be obtained from a proper definition of the geological environment in the subsurface.

The main effect of variations in permeability is the bending of flow lines in such a way that the fluid mass is conserved when water flows across a boundary between strata of different permeability (Hubbert, 1940).

Figure 4 (after Freeze and Whitherspoon, 1967), shows a number of numerically simulated two-dimensional flow nets for heterogeneous geological systems, Figures 4 (a) and (b) show the fluid potential distribution in the subsurface with a highly permeable layer (aquifer) underlying a low permeability sediment (aquitard), but with different configurations of surface topography. A comparison between Figures 4 (a) and 4 (b) shows that in a similar geological setting topography greatly complicates the groundwater flow pattern. Furthermore, a highly permeable layer at depth acts as a major conduit for flow that passes under overlying local systems.

Figures 4 (c) and (d) show the effect of high permeability discontinuities on the groundwater flow pattern. In both instances, upward flow occurs near the downslope part of the high permeability discontinuity. Such middle slope discharge areas at surface cannot occur under purely topographic control.

Figures 4 (e) and (f) show the effect of sloping stratigraphy on the groundwater flow pattern. As can be seen in these figures, the direction of the slope of the highly permeable bed with respect to the recharge, or topographically high, area strongly affects the potential distribution within the subsurface.

The foregoing examples show that geological heterogeneity and topography have a pronounced effect on local and regional groundwater flow systems. Furthermore, it becomes apparent that, in order to be able to describe a groundwater flow system in any given area, knowledge of the distribution of the permeability in space is mandatory.

Permeability, as has been shown in the previous paragraphs, is one of the controlling factors in groundwater flow. Different types of permeability can be recognized. They are related to the mode of deposition, type of sediment and rock, post-depositional processes, and tectonic stresses. Figure 5 shows the different types of permeability and porosity. The significance of the different types of permeability will be shown below.

The rate of groundwater flow is a function of the available hydraulic head and the permeability distribution in an area. It varies from several tens of metres to a fraction of a centimetre per year. It is obvious from the foregoing that in any groundwater flow system the rate will be primarily controlled by the lowest permeability of the series of permeabilities encountered by the groundwater traveling from the recharge to the discharge area. Furthermore, the bulk of groundwater flow will be concentrated in the areas with the highest permeable paths, i.e. where the least amount of energy needs to be expended.

II. AQUIFERS

In the previous chapter the rudimentary principles of groundwater flow were explained. It should be pointed out that groundwater flow occurs in all sediments and rocks. The zone in the subsurface from which groundwater is obtained is called an aquifer.

An aquifer is any water-saturated body of geological material from which enough water can be drawn at a reasonable cost for the purpose required (Brown, 1967). An aquifer therefore is only a relative term, determined largely by economics and alternate sources. For example, in areas where water is scarce, a zone which can supply only enough water for daily domestic use (400-900 litres) is considered an aquifer. However, the same zone would not be considered an aquifer if multiples of the previously mentioned volume are required.

Three major types of aquifers are commonly recognized: unconfined, confined,and leaky (Fig. 6). Proper identification is important from a technical, managerial, and legal point of view because hydrologically they react in considerably different ways.

An unconfined or watertable aquifer has a free water surface, the water-table,exposed to the soil atmosphere. Water is released from the aquifer primarily by gravity drainage.

A confined, or artesian, aquifer is enclosed by layers of such low permeability that the water is confined to the intervening more permeable zone and under hydrostatic pressure in a manner similar to water in a tilted pipe. In other words, a well completed in a confined aquifer shows a static

water level at an elevation higher than the top of the aquifer. Withdrawal of water from a confined aquifer results in a lowering of the hydraulic head. Depending on the degree of the lowering of the hydraulic head in the pumping well the effect may be noticed over a wide area.

A leaky confined aquifer is closely related to a confined aquifer. It differs from a confined aquifer in that the "confining" beds have a sufficiently large vertical permeability that as a result of lowering of the hydraulic head in the aquifer water will move through the "confining" beds toward the aquifer. In other words, recharge to the aquifer takes place through the "confining" beds. Under similar conditions of initial head distribution, permeability, thickness, and pumping rate, the effect of the lowering of the hydraulic head due to pumping will not be as wide-spread in a leaky "confined" aquifer as in a confined aquifer. It should be pointed out that in the writer's opinion truly confined aquifers do not exist. The assignment of the label "leaky" is time dependent. Given sufficient time almost all confined aquifers will show a degree of leakage under stressed conditions.

In addition, certain characteristics unique to the geological environment in which the aquifer is found have a strong bearing on its character and permeability distribution, on recharge phenomena, and on its behaviour under stress, environmental sensitivity and productivity and, last but not least, on exploration strategy. Four main geological aquifer environments can be recognized.

Clastic sedimentary environment. The chief characteristic of sedimentary deposits is that they occur in comparatively thin sheets that may be of relatively great lateral extent. Most sediments in this environment are deposited in bodies of salt or fresh

water. Aeolian deposits, for example dunes, are an exception. The material comprising the sediment is transported mechanically, by water or wind, and is sorted with distance from its primary source. The ability to store and transmit water depends on the size, shape, and sorting of the constituent particles. Groundwater flow in this type of sediment in intergranular. Post-depositional changes, such as cementation, can significantly alter these parameters, as can subsequent tectonic events such as fracturing and faulting. However, not all sediments deposited in water are characterized by the above-mentioned degree of homogeneity. Fluvial sediments, and especially glacio-fluvial deposits, are noted for their rapid change in type of sediment and uniformity in both a lateral and a vertical sense. Understanding the local depositional environment, the sedimentation processes, and the geological history is therefore of paramount importance in the evaluation of the groundwater potential of a clastic sedimentary area.

Limestone and dolomite environment. The sediments in this environment, although belonging to the sedimentary environment in a geological sense, are discussed separately because of a number of processes which have a strong bearing on the flow of water. Limstone is formed by organisms which extract calcium carbonate from sea water. Penecontemporaneous erosion of the calcium carbonate deposits generally results in a highly complex sequence of calcareous deposits. Primary porosity, and permeability, are the result of the openings left by the organisms which originally built the carbonate rock. In the reworked carbonates the porosity is similar in origin to the porosity in clastic sediments. However, most limestones show considerable

secondary cementation and recrystallization, which has destroyed most of the primary porosity. Two processes which can drastically increase the porosity and permeability of limstones are dolomitization and karstification. Dolomitization is a diagenetic change during which calcium carbonate is replaced by magnesium-calcium carbonate (Morrow, 1982a). The origin of the majority of dolomites in the world is due to this process. Almost all models developed to explain this process require groundwater flow (fresh and/or saline) as the mechanism to introduce and supply the magnesium ions to the calcium carbonates (Morrow, 1982b). Dolomites in most instances are not a primary deposit but are formed penecontemporaneously or later due to diagenetic changes.

Dolomites can have a much higher permeability than limestones. According to Wardlaw (1979),this may be related to the idiomorphic shape and uniformity in size of the dolomite crystals. Intercrystalline porosity as high as 25 percent has been observed by the writer in several dolomites in Alberta.

Karstification is a process of leaching and decalcification of easily leachable rocks. It results in the formation of solution channels, cavity development, collapse structures, etc. Karstification dramatically increases the ability of limestones and dolomites to transmit groundwater. Very large volumes of water can be obtained from karstified limestones and dolomites. Many solution channels and cavities in karst areas are partially infilled with clastic material. During pumping this sediment can be removed, which results in an increase of the "permeability" (Weyer, 1983).

Crystalline (igneous and metamorphic) rock environment. The greater part of the surface of Canada is underlain by igneous and metamorphic rocks. They are the only potential aquifers in those areas where surficial sediments are thin or lacking. In contrast to the intergranular permeability of sedimentary rocks, crystalline rock environments exhibit primarily fracture permeability and porosity. The distribution of the primary macroscopic fracture permeability is a function of the tectonic and associated intrusive history, the degree of metamorphism, and the lithofacies in any given area. Although on a unit volume basis the permeability and porosity of crystalline rocks are small in comparison to those of unconsolidated sedimentary deposits, large volumes of water can be transmitted. Evidence of this is provided by the volumes of water pumped out of mines in this environment. Daily volumes range from 50,000 to 20,000,000 litres (Brown, 1967). For a more detailed and in-depth discussion of groundwater flow in fractured rock the reader is referred to Gale (1982).

Fractured sedimentary rocks. Fractured sedimentary rocks form a separate environment, which has characteristics of both the unconsolidated clastic sedimentary deposits and fractured crystalline rocks. The sediments in this environment have undergone considerable diagenetic change. Cementation of the coarser-grained facies is common and the sediments are generally consolidated. Intergranular porosity and permeability are generally considerably less than in their unconsolidated equivalents. However, due to tectonic stresses and deformation, extensive fracture patterns have developed in these environments, which greatly facilitate the movement of water.

It should be pointed out that fracturing of sedimentary deposits is

not restricted to those beds that are consolidated. Many tills (unconsolidated Pleistocene sediments) also show fracturing (Grisak et al., 1975; Vonhof, 1983). This aspect has considerable bearing on waste disposal practices in areas underlain by till. Furthermore, many clay-rich surficial unconsolidated sediments in Canada are subjected to drying cycles. This results in the development of a polygonal network of vertical desiccation cracks. Some of these cracks extend to depths of more than 10 metres. In many instances the cracks are infilled with organic matter and other sediment. The permeability of the infill material is generally orders of magnitude higher than that of the surrounding sediment. The desiccation cracks play a vital role in establishing and maintaining a moisture balance in the clay-rich sediments. The network of desiccation cracks, however, also provides relatively highly permeable pathways for contaminant transport in an otherwise very slightly permeable ("impermeable") environment.

The geological history of Canada determines the areal distribution of the main aquifer environments described above.

- The Cordilleran Region (primarily British Columbia and the Yukon) is characterized by crystalline and folded sedimentary rocks. However, because of population distribution, most groundwater is obtained from Pleistocene and Holocene sediment fill in valleys.
- The Interior Plains (Alberta, part of the Northwest Territories, southern Saskatchewan, and southwestern Manitoba) comprise essentially flat-lying unconsolidated and semi-consolidated sedimentary rocks. The majority of the groundwater is obtained from aquifers within the Pleistocene section.

- The Canadian Shield (northern Saskatchewan, the Northwest Territories, most of Manitoba, Ontario, Quebec, and Newfoundland) falls within the crystalline rock environment. In places glacial outwash, kames, and eskers are used as aquifers.
- The St. Laurence Lowland (southern Ontario and parts of Quebec) is primarily comprised of sedimentary rocks. Groundwater is obtained from unconsolidated aquifers (sand and gravel deposits of Pleistocene age) and consolidated limestone and dolomite aquifers.
- The Appalachian Region (New Brunswick, Nova Scotia, the island of Newfoundland, and Prince Edward Island) is characterized by mixed crystalline and folded sedimentary rocks and by flat-lying semi-consolidated sedimentary rocks (part of New Brunswick and Prince Edward Island). However, the generally fine-grained semi-consolidated flat-lying sedimentary beds are intensely fractured, which greatly contributes to their value as aquifers.

The areal distribution of the above physiographic regions is shown in Figure 7.

Groundwater is an important resource in Canada. Data collected by Hess (1984) show that approximately 33 percent of the Canadian population uses groundwater. Figure 8 illustrates the percentage of groundwater versus the total volume of water used by the population in each province. As can be seen, groundwater constitutes a very important resource in most provinces, which becomes even more significant when it is realized that 90 percent of the rural population relies entirely on groundwater (Hess, 1984).

III. IMPLICATIONS OF EXTRACTION OF GROUNDWATER

3.1 Introduction

Groundwater extraction by pumping from a well causes a lowering of the fluid potential or the hydraulic head in an aquifer (Fig. 9). The amount of decline is termed drawdown. The effect is strongest at the pumping well and decreases exponentially with distance from the pumping well. The area experiencing drawdown is called the cone of depression or cone of influence. With continued pumping the cone of depression deepens until a state of equilibrium is reached between inflowing groundwater and the pumping rate. The areal extent and the degree of deepening of the cone of influence is a function of the production rate, permeability, thickness, type of aquifer, available drawdown, size of the aquifer, rate of recharge, etc. For example, if all parameters are equal except permeability, the drawdown will be greater in the vicinity of the pumped well and less at great distances from it in the case of an aquifer with lower permeability.

By observing and measuring the change in the drawdown with time in observation wells completed in the aquifer at different distances from the pumping well, the safe yield of the aquifer can be determined. Several analytical methods have been developed for various aquifer configurations and boundary conditions to interpret the drawdown data (Kruseman and DeRidder, 1970; Walton, 1970). It should be realized, however, that most theories of aquifer analysis assume a high degree of uniformity in the aquifer characteristics and parameters, which is a condition rarely met in the natural environment. In spite of this drawback, the analysis and

evaluation of pumptests conducted in aquifers in unconsolidated sedimentary environments is sufficiently developed that reasonable estimates of the safe yield can generally be obtained. In many instances computer modelling graetly facilitates the aquifer interpretation, provided that the hydrogeological environment is well defined. This requires, however, not only that the modeller understands the limitations of the model, but also has a very thorough understanding of the geological environment he is dealing with. Unfortunately this combination of requirements is rarely met.

In contrast, interpretation of aquifer tests in fractured geological environments and karstic dolomites and limestones is still in its infancy (Gringarten, 1982). Similarly, groundwater flow in these media is not fully understood. This may in part be due to the much greater complexity of these environments compared to unconsolidated and semi-consolidated sedimentary environments, which in turn has resulted in slower advance of theoretical development. Futrhermore, the distribution of the permeability and its magnitude in space is due to post-depositional phenomena and not necessarily related to a specific lithofacies.In order to define the hydrogeological environment of such areas a much greater number of data points is required, which is inherently more costly. Accessibility is generally poor, which hampers the proper distribution of data points, and the material to be drilled often requires specialized drilling equipment. In addition much of the area underlain by potential fractured crystalline and sedimentary rock aquifers, at least 95 percent in Canada, is at best sparsely populated. Exceptions are Prince Edward Island and parts of New Brunswick and Nova Scotia. Furthermore,

especially in the largest crystalline rock region, the Canadian Shield, there is often an abundance of surface water. Similarly, the areas immediately underlain by karstic limestones and dolomites are in remote parts of the country, in the Mackenzie Mountains, the Yukon (Ford and Quinlan, 1977), the Great Bear Lake area, N.W.T. (van Everdingen, 1981), the Pine Point area, N.W.T. (Weyer, 1983), and northern Alberta (Ozoray, 1977 a and b).

However, remoteness or lack of population does not necessarily mean that no groundwater problems exist. This is illustrated by the experience of the mining industry in some of these areas. As mentioned before, several mines in fractured crystalline rock environments experience significant groundwater inflow. Individual rates range from 5×10^4 to 2×10^7 litres/day. The largest groundwater inflow in a mine in Canada known to the writer occurs in the Pine Point area (Weyer, 1983). The Pine Point ore bodies are located within karstic dolomite and limestone. In order to extract the ore, the ore bodies are dewatered. Daily groundwater extraction over the period 1971-1980 averaged 2 to 3×10^8 litres.

In the past the main concern of the mining industry with respect to groundwater inflow problems has usually been the size of the pump(s) required to get rid of the water and little attention was paid to the effect of dewatering on the regional environment. However, present environmental regulations require that this aspect is considered. Examples of detailed evaluations of the regional effects of major dewatering operations are the Cominco mine in the Pine Point area, N.W.T. (Weyer, 1983), the Saskatchewan Power lignite-fired thermal power plant in southeastern Saskatchewan (Int. Joint Commission, 1979), the open-pit Uranium mines in northern Saskatchewan, and the tarsand area of northeastern Alberta. All studies show that the areas

affected by dewatering range from several tens to hundreds of square kilometers.

The effects of karstification are not restricted to near surface environments. Salt karst developed and developing in the Prairie Evaporite Formation as a result of deep groundwater flow systems has resulted in the removal of the salt beds and subsequent collapse of the overlying strata (Holter, 1979; Baar, 1972; Christiansen, 1967, 1971; Gendzwill and Hajnal, 1971; Weyer, 1983). Where the collapse structures have not been healed subsequently by salt they represent highly permeable paths to groundwater flow. In areas where mining activity occurs, the "open" collapse structures represent potentially dangerous situations. Recently, in the Fall of 1984, one of these open systems was encountered at a mine of the Potash Corporation of Saskatchewan in southeastern Saskatchewan. The inflow of salt water was 2,500 L/min at the start and increased to 13,000 L/min ($3.6 - 18 \times 10^6$ L/day). At this time it is not known what the long-term effect of this will be on the mining operation.

Within the last ten years, major studies of groundwater flow within fractured crystalline rock environments have been initiated in Canada (Davison, 1984; Francis et al., 1984; Kohut et al., 1984; and Pearson, 1984). Several of these studies were initiated to determine the effect of the groundwater flow and subsurface geochemical environment on the long-term integrity of a repository for high-level nuclear waste located deep within plutonic rock in the Canadian Shield. It is hoped that the results of these studies will have universal applicability to flow in fractured rock. There is a considerable need for this type of information in order to properly manage the groundwater resources in fractured rock environments, not only in

Canada (the maritime provinces and especially Prince Edward Island, which obtains almost all its water from such an environment), but also in other parts of the world, for example India and many parts of Africa.

From the foregoing it is apparent that the effect of lowering of the fluid potential can be reasonably well predicted and projected in geological environments with intergranular groundwater flow, i.e. unconsolidated to semi-consolidated sedimentary environments, but the same is not true for fractured crystalline and sedimentary rocks and karstic environments.

It was mentioned previously that the lowering of the fluid potential results in a cone of depression. Under ideal conditions, in a homogeneous and isotropic aquifer, that is one with uniform permeability, of very large ("infinite") areal extent, the shape of this cone is circular in plan view. In a natural environment, however, the transmissivity (= permeability times thickness of the aquifer) generally has a directional distribution which is due to the type of depositional environment and depositional history of the sediments, preferred fracture orientations and variations in density and aperture, or directional occurrence of solution phenomena (karst). Extraction of groundwater from this type of environment will create a cone of depression which, in terms of shape, approximates the distribution of the directional transmissivity. This means that in fractured media and also in karstic terrain, which generally exhibits even stronger directional transmissivity, cigar-shaped to almost "linear" cones of depression can be expected. An approximation of the position and shape of a cone of depression can generally be inferred from the properly defined geological environment.

Knowledge of the shape, size, and areal distribution of the cone of

depression is important for groundwater management purposes (safe yield, interference, streamflow interception, saltwater intrusion, etc.) and environmental considerations (subsidence, contaminant transport, siting of waste disposal locations, etc.).

3.2 Groundwater - Streamflow Interaction

Water in steams (and lakes) originates as surface runoff, groundwater discharge, direct precipitation, and in places as municipal-industrial-agricultural effluent. Each stream has a groundwater discharge component, which is generally called the base flow. According to Newbury et al. (1969) the base flow receives its water from:

- transient bank storage,
- transient groundwater storage caused by rapid watertable rise following infiltration of precipitation, which is generally rapidly dissipated,
- groundwater stored within the sediments of the basin, which, according to the principles of groundwater flow, will move toward the topographically low area, i.e. the stream.

Freeze (1972) has shown that surface runoff in base-flow dominant streams is strongly influenced by the subsurface hydrogeological configuration, the saturated permeabilities of the formations, and the unsaturated soil characteristics of the soil types in the catchment basin. He further indicated the prominent role played by subsurface flows in generation of surface runoff. This mechanism can create such wide variations in watershed response to

precipitation events that simple functional relationships cannot be identified. Freeze (1972, 1974) suggests the use of more physically-based models to obtain more meaningfull interpretations.

In surface drainage basins where the chemistry of both the groundwater and surface water is known, the surface-water chemistry closely resembles that of groundwater during base flow periods. This is especially noticeable during the winter months when there is no direct surface runoff component. The variation in ionic content in a stream over a period of a year is primarily due to the dilution effect by fresh runoff water (precipitation and snowmelt). It follows therefore that excessive withdrawal of surface water from streams will result in a proportionally larger groundwater component in the stream. Because the ion concentration is generally considerably higher in groundwater than in surface water, this will result in a deterioration of the water quality of the stream for downstream users. The writer is not aware of any studies assessing the economic aspects of such a scenario. It is expected that, with the increased demand for "good" quality water, i.e. surface water, in western Canada, in the long term quality of stream and river water will deteriorate.

Figure 10 shows conceptually the relationship between groundwater discharge and streamflow for various river stages. Also shown is the effect of a pumping well close to the river or stream. If an aquifer is connected with a river, the lowering of the fluid potential can result in a reversal of groundwater flow, i.e. non-pumping flow toward the river and pumping flow from the river toward the well. The latter is called induced infiltration.

If a large volume of water is pumped from wells located near a river or stream, the streamflow will be reduced, not only as a result of induced infiltration, but also by the interception of the groundwater in the aquifer, which under non-pumping conditions would discharge into the river. It has, however, been found by the writer that in aquifers which are in direct connection with a river and receive most of their water from the river by induced infiltration, the infiltration capacity of the riverbed varies throughout the year. This is due in part to a decrease in the surface area available for infiltration, as a result of the lowering of the river stage. Secondly, due to reduced flow rates in the river, the sediment carried by the water becomes progressively finer (Blackford and Ongley, 1984), which results in finer material being deposited in the river channel. This in turn reduces the permeability of the riverbed material and hence the infiltration rate.

Damming a river to build a reservoir creates significant changes in the groundwater flow regime in the area. This phenomenon was investigated during the filling of Diefenbaker Lake in the South Saskatchewan River valley (van Everdingen, 1972 a). The results of this study showed that as a result of the additional head provided by the level of the water in the reservoir the groundwater flow regime was changed drastically. It has resulted in higher water levels (increased fluid potential) in the aquifers in the vicinity of the reservoir, causing some wells to start flowing. Overall vertical gradients below the reservoir have been reduced, with a resulting decrease in the rate of discharge from the aquifers to the river valley. Similarly, lateral gradients in several aquifers have been reduced, leading

to a decrease in the rate of groundwater movement toward the valley.

The above examples of interference by man in the interaction between groundwater-streamflow systems show that there is a direct cause-and-effect relationship with predictable consequences. Knowledge of this interaction has forced water management boards, especially in densely populated areas in the world, to consider the total resource of water, i.e. groundwater and surface water, in a river catchment basin as an integrated system, in order to properly plan the multiple use of water and avoid imbalances and consequently deleterious side-effects by overemphasis on one source only (Skinner, 1983). It appears that in Canada this approach is lacking in water resource management. This may be due to the fact that the densely populated areas in Canada generally occur in regions with abundant surface-water resources. Freshwater supply management has therefore traditionally concentrated on surface water. This approach still holds true for most of the country. For example,where a choice is available surface water will invariably be chosen over groundwater as a source. Although the vital link between groundwater flow and surface water flow has been proven many times in various parts of the world, it has received little attention in Canada. This may be due in part to a lack of understanding of the interaction between surface and groundwater flow, and in part to the fact that the existing data base is insufficient to show the long-term effects of the modification of surface flow systems on groundwater supplies and vice versa. The insufficient data base is furthermore hampered by a lack of interest from the scientific hydrological community in long-term (10-20 years or more) projects to collect the necessary data, and by the lack of interest of

governments to commit funds for long-term studies.

3.3 Subsidence

Subsidence of the land surface occurs in many parts of the world. It is caused by tectonic movement, solution, mining, compaction of sediments due to static loading, vibrations, or increased density brought about by watertable lowering, and changes in reservoir pressure with loss of fluids (Domenico, 1972). Major subsidence attributed to the latter cause has been reported for various parts of the world. It is not restricted to groundwater withdrawal, but also occurs as a result of oil and gas exploitation. The maximum subsidence reported as a result of crude oil extraction is 8.8 metres at the Wilmington field in Long Beach, California (Yerkes and Castle, 1969). Gas fields which have shown subsidence are the Groningen gas field, the Netherlands (Schoonbeek, 1977) and the Po Delta gas field, Italy (Poland and Davis, 1969).

The best known examples of subsidence caused by groundwater withdrawal in North America are the Houston-Galveston area, Texas (Gabrysh and Bonnet, 1975) and the San Joaquin Valley in California (Poland et al., 1975). In the Houston-Galveston area , an area of 12,200 km^2 subsided more than 0.15 metres. An area of approximately 45 km^2 shows subsidence greater than 2.5 metres. Several oil and gas fields are present in the same area and

their possible contribution to subsidence has also been investigated (Holzer and Bluntzer, 1984). It was found that of the 29 oil and gas fields only six caused additional local subsidence, but that the main cause of subsidence was groundwater withdrawal.

In the San Joaquin Valley, an area of 13,450 km^2 subsided more than 0.30 metres. The maximum subsidence which has been measured is 8.8 metres.

Subsidence creates serious and costly problems. The normal upward force of skin friction acting on piles or well casings may be reversed, which will subject these elements to "downdrag" (Domenico, 1972). This results in failure and collapse of casings and protrusion of structures above the land surface. Gradients in canals, for example for irrigation, and streams will be reduced or in the worst cases reversed, thus affecting the normal flow of water. Cracking of concrete or brick structures, sewer- and water lines is also likely to occur. In the San Joaquin Valley up until 1972 millions of dollars have been spent on the repair or replacement of deep water wells alone (Poland et al., 1975).

Subsidence is caused by the compaction of sediments, primarily clay-rich deposits. An increase in grain-to-grain load, i.e. an increase in effective stress, results in compaction. Terzaghi (1925) introduced the theory of effective stress:

$$p = p' + Uw$$

where p = total stress (geostatic pressure), p' = effective stress (effective overburden pressure or grain-to-grain loading), and Uw - pore pressure (fluid pressure or neutral stress). In a confined aquifer the lowering of the hydraulic head by pumping will not appreciably change the geostatic pressure

(Poland and Davis, 1969). Therefore, the increase in effective stress within confined aquifers is directly due to the decrease in fluid pressure (hydraulic head). This results in immediate compaction of the sediment, which in turn causes a partial loss of porosity. The magnitude of compaction is dependent on the compressibility of the sediments. However, if the fluid pressure is restored, much, but not all, of the compaction can be recovered due to the elastic nature of the sediment.

On the other hand, in clay-rich interbeds and confining beds with very low vertical permeability and high porosity, i.e. relatively recent sediments which have not undergone significant compaction, the vertical flow of water toward the aquifer induced by the lowering of the fluid potential is slow and the adjustment of pore pressures is also slow and time-dependent. Hence the stress increase in the fine-grained sediments induced by the lowering of the fluid potential in the aquifer becomes effective only as rapidly as pore pressure decay toward an equilibrium. This process may take months or years depending on the magnitude of the vertical permeability. The steady increase in effective stress (grain-to-grain loading) results in a gradual reduction of porosity, i.e. compaction of the fine-grained sediments. Since the initial porosity of these sediments is relatively high, generally much higher than that of the aquifer, a considerable volume reduction occurs in the very fine-grained clay-rich beds, which is the main cause of subsidence.

To arrest the compaction and thus subsidence, the hydraulic head in the aquifer has to be restored to such a level that it equals the maximum pore pressure in the confining beds and/or clayey interbeds. However,

due to various factors (Poland and Davis, 1969) which will not be further discussed here, the compaction of clay-rich sediments is not elastic and the initial porosity of the beds cannot be restored.

Proper investigation of a hydrogeological environment can generally predict the severity of subsidence.

Not much is known about areas in Canada where subsidence as a result of groundwater withdrawal may be causing major problems, nor is it known if oil and gas production may have caused significant, or at least measurable, subsidence. Logic suggests that this phenomenon should be occurring, but it has apparently not reached sufficient magnitude to attract attention.

One documented case of subsidence due to changes in the fluid potential was recorded by B.C. Hydro in the Downey Slide, which is located approximately 50 km north of Revelstoke, B.C. The slide is being dewatered continuously by means of drainage adits to avoid possible reactivation as a result of the presence of a newly constructed reservoir. The slide is composed of metamorphic rocks (mica schists, quartzites, etc.). A first order geodetic survey showed that dewatering over the period 1975 - 1984 resulted in a settlement of 6 cm. The watertable was lowered 100 m over an area of approximately 1 km^2, during this period.

3.4 Seawater Intrusion

Aquifers in coastal areas which are connected with the sea or ocean are subject to seawater intrusion. Figure 11 shows the idealized concept

of the freshwater-saltwater interface, the head distribution and the flow of both the freshwater and saltwater in a coastal aquifer. The contact between the freshwater and saltwater is generally not well defined and is characterized by a zone of transition. This is due to dispersion and diffusion effects. Dispersion is much enhanced by the back-and-forth movement of the water as a result of tidal and seasonal fluctuations (Van der Kamp, 1981). In areas where both fracture and intergranular permeability are present, the effect of dispersion is generally enhanced, because the flow takes place largely in the fractures, whereas most of the water is stored in the intergranular porosity.

The extent of the wedge of saltwater is determined by the hydraulic-head relationship between the seawater phase and the freshwater phase.

In coastal areas where multiple aquifers are in hydraulic connection with the sea, complex distributions of freshwater/seawater contacts often occur. This is illustrated in Figure 12, showing a cross-section located near York Point, beside the estuary of the North River, on Prince Edward Island (Van der Kamp, 1981). As can be seen in this figure, the salinities indicate various degrees of seawater intrusion. No groundwater is extracted from any of the aquifers in the immediate area. It appears therefore that the distribution of the saline water is entirely due to natural processes.

The landward flow of seawater in the deeper aquifers can be explained in part as the result of entrainment through dispersion (Kohout, 1960). However, variations in annual precipitation could also have significant effect on the position and movement of saltwater in coastal aquifers. Infiltration of rainfall and/or snowmelt to the water-table results in a

rise in the level of the water-table. This in turn provides additional head, which will result in "pushing back" of the freshwater/saltwater interface toward the sea. On the other hand, years with below average precipitation, i.e. recharge, will result in the opposite effect. Another possible explanation is the effect of rising sea levels. According to Dohler and Ku (1970), the sea level at Charlottetown has been rising about 30 cm per century. This means that the saltwater must be steadily penetrating farther inland in the aquifers because of both the coastline recession and the increased head of the seawater (Van der Kamp, 1981).

From the foregoing it is obvious that the freshwater/seawater interface is a dynamic entity and that its position is determined by the unique hydrogeological environment of the area. It is therefore also apparent that if the head in the freshwater flow system is changed by man, this will have an immediate effect on the position of the freshwater/saltwater interface. Figure 13 shows conceptually the change in the position of the seawater wedge in an unconfined and in a confined aquifer under pumping conditions. It should be realized that the movement of the freshwater/saltwater interface cannot be prevented. The rate of movement, however, can be controlled by the pumping rate, i.e. by the amount of change in the hydraulic head. The effects of seawater intrusion therefore become a groundwater management problem. Excess production will lead inevitably to contamination by seawater. Cessation of pumping will eventually re-establish the pre-pumping freshwater/saltwater distribution.

There are a number of methods available to control seawater intrusion (Kashef, 1971, 1975, 1976; Todd, 1974; Vandenberg , 1975). These methods

involve schemes where the position of the freshwater/saltwater interface is manipulated by recharge to and/or discharge from the aquifer in the area between the pumpwell and the coastline. Several of these schemes are outlined conceptually in Figure 14. Recharge methods to arrest seawater intrusion have thus far not been used in Canada. In other parts of the world, for example the West Coast Basin, California, the Biscayne aquifer, Florida, and dune aquifers along the coast in the Netherlands, recharge schemes are used effectively to prevent seawater intrusion.

Not all intruding seawater flows laterally toward a pumping well. In several instances upconing of seawater, or of saline water in non-coastal areas, has occurred toward wells where the freshwater aquifer is underlain by saline water-bearing strata (Todd, 1974; Streltsova and Kashef, 1974). The combination of leaky confining beds and the upward gradient created by the lowering of the hydraulic head in the well will cause this phenomenon. Reduction in the pumping rate is the simplest control method.

It is obvious from the foregoing that, with all parameters being equal, the safe production yield of an aquifer in a coastal area will generally be less than that for a similar aquifer in a continental region. To avoid the problem of seawater intrusion, the groundwater extraction rate has to be managed carefully. Alternatively, a control program to prevent seawater intrusion has to be employed.

3.5 Artificial Recharge

If the production from an aquifer exceeds the natural recharge, then the production rate is gradually reduced until a new equilibrium is reached, or a program of artificial recharge can be initiated.

Artificial recharge can be accomplished by either one of two basic methods: pit spreading and injection wells. In pit spreading, water is commonly diverted from a stream or released from a reservoir to shallow basins or trenches. The recharge water infiltrates through the bottom of the basin or trench and migrates downward to the water-table. Most spreading basins or trenches are modified to a rapid sand-filter system constructed on the natural soil material. When the infiltration rate declines, the basins are allowed to dry and are subsequently cleaned. Scraping, plowing, and disking are used to increase the permeability.

The infiltration rate is dependent upon the depth of the water in the basin, the vertical permeability, and the geochemical, biological, and physical changes that take place. To operate recharge ponds effectively, the water should be pretreated, primarily to remove sediment particles which can rapidly clog the sediment in the basin or pond. One of the main problems with recharge ponds or trenches is the growth of algae, which rapidly reduces the permeability of the sediments. The algal growth is primarily due to the fact that the surface water used generally has a considerable nutrient load. Covered seepage trenches have been used successfully in Germany to avoid this problem (Hantke, 1983).

The quality of the recharge water should meet drinking water standards.

It has very little sense to introduce contaminated water into the subsurface. Although the possibility of attenuation exists for certain constituents in a contaminant load moving through the subsurface, there is no guarantee that this will result in complete removal. In areas where urban storm-runoff is used for artificial recharge, for example in Fresno, California, it was found that significant amounts of lead, zinc, and copper had accumulated in the sediments in the retention basins (Nightingale, 1975). Studies of the soil profiles suggest that a considerable portion of the heavy metal load is retained by the soil. However, it is not known how much is being recharged to the aquifer.

Unwanted artificial recharge to the shallow subsurface is occurring in many irrigation districts. During the time of the year when the irrigation ditches and canals are filled with water they act in the same way as recharge trenches; in those parts of the ditches where significant permeability exists recharge occurs. This has led to loss of arable land due to salinization and alkalinization resulting from the combined effects of induced groundwater flow (i.e. a constant supply of ions)and evaporation.

The other method of artificial recharge is by means of injection wells. Such wells are used in localities where there are zones between the surface and the aquifer with such low permeability that vertical movement of water is too severely retarded. The injection wells are completed in the aquifer which is also used for groundwater withdrawal. Water used for injection has to be of high quality and chemically compatible with the aquifer water, otherwise clogging occurs (Warner, 1966, Rebhun and Schwartz, 1968). Other potential causes of problems with injection wells are:

- Suspended sediment. This has to be very low to avoid plugging of the pore spaces and/or fractures in the sediment around the well bore.
- Bacterial nutrients and bacteria. Slime formation in and around the well bore leads to clogging.
- Entrapped air. This causes clogging in the sediments surrounding the well bore.

It is obvious from the above that the level of treatment of water used for artificial recharge has to be much higher for injection wells than for surface methods. The greatest success with injection wells has been achieved in carbonate aquifers, which are less susceptible to the problems outlined above because of the presence of secondary (solution) permeability (karstification) .

Infiltration basins for artificial recharge were first used in Germany in 1875 (Hantke, 1983). Since then various countries in the world have been using artificial recharge to augment their groundwater resources, to improve the quality of the groundwater, or to prevent seawater intrusion. In most countries, recharge is accomplished through sand and gravel. In Germany, Switzerland, Australia, and the Netherlands, basins and canals are preferred, whereas in Great Britain, Japan, Jamaica, and Israel,wells are primarily used. In the latter countries injection is mainly in carbonate aquifers. In the United States, U.S.S.R., and France, both basins and wells are used because of the wide diversity of aquifer formations being recharged (Brown and Signor, 1974). In some countries in western Europe, artificial recharge accounts for 20-40 percent of the total water requirements.

Artificial recharge has a number of advantages over surface storage schemes. These are:

- Elimination of losses through evaporation.

- Temperature equalization. River water temperature can fluctuate from 0 to 25° C. Heat exchange in the subsurface, depending on the residence time, reduces this range to about 8 to 15° C.
- Breakdown of organic compounds, denitrification and sulfate reduction. This occurs as a result of anaerobic and aerobic biochemical activity.
- Significant colour and taste improvement of surface water after passage underground.

In the past, it has also been assumed that bacterial and viral pathogens present in surface water would be destroyed after entering the subsurface. Recent studies, however, have shown that these bacteria and viruses do survive for prolonged periods of time in a groundwater environment (Bitton et al., 1983).

In areas where surface water/groundwater systems are managed as a single unit, artificial recharge is also used as a method to store excess runoff water which can then be extracted again during periods of low flow.

Experience in many parts of the world has shown that, although surface water has to be treated for artificial recharge, the total level of treatment is considerably less than that required for direct consumptive use of surface water. Furthermore, from the point of view of land use, artificial recharge storage schemes require only a fraction of the surface area that would be necessary for the equivalent volume storage in surface reservoirs. Also, artificial recharge is used successfully to replenish depleting groundwater resources in the world and at the same time to arrest the effects of subsidence and seawater intrusion that result from groundwater extraction.

Artificial recharge occurs in Canada mainly as a side-effect of irrigation. It is practiced to supplement groundwater resources in only a few areas, for example the Trenton-Aylmer area in Ontario and in Camrose, Alberta. The Camrose facility has successfully operated since 1958. Water is pumped from a lake into pits in a gravel terrace aquifer,at a rate ranging from 60-120 L/sec., to recharge the aquifer (Gabert, 1982). In Canada, when problems of groundwater supply are envisaged, the tendency thus far has been to switch to surface water supplies rather than to investigate the possibility of, for example, artificial recharge. Groundwater per se and groundwater flow are still considered by many as something mysterious and not as a commodity that can be dealt with in a rigorous scientific way and with an engineering technical approach. The attitude that "you cannot see it, therefore you cannot count on it" by civic administrations and (surface) water management groups has led to a reluctance to provide sufficient funds for a proper evaluation of the groundwater resources in many parts of the country. This is illustrated, for example, in the Kitchener-Waterloo region in Ontario (Farvolden, 1982). This region obtains its municipal water supplies from wells in Quaternary gravels. There is a justified concern that future needs cannot be met unless a new source is found. The favoured solution is a pipeline at a cost of several hundred million dollars to Lake Erie. However, it is felt by many geologists and engineers that additional groundwater supplies are available which perhaps are sufficient to meet future demands and which could be developed at a fraction of the cost of a pipeline. The problem is that there is an insufficient data base to properly assess the groundwater potential of the area. According to Farvolden

(1982, p. 68), " . . . Funds have not been made available for basic stratigraphic studies using modern techniques, and as a consequence hydrogeology cannot be used effectively in dealing with this problem. The inadequacy of geologic data is not limited to this region. Basic geologic mapping is lacking generally for assessment, development, and protection of our groundwater resources and somehow we have to convince government officials and funding agencies that it will pay to correct this deficiency . . . ". It is ironic that when funds are needed to define the geology for remedial measures after groundwater pollution has occurred, they are generally readily made available, but that there is great reluctance to spend money on studies which are directed toward prevention of such problems.

IV. GROUNDWATER CONTAMINATION

4.1 Introduction

Parallel with the physical flow of groundwater there is its geochemical evolution which determines the quality of the water that occurs at any point in time and space. The natural quality and composition of groundwater is determined by the type of soluble substances the water encounters, the distance it travels, its subsurface residence time, and a host of physico-chemical processes that involve both the water and the sediment matrix. On a local scale, groundwater is characterized by nearly constant chemical and physical properties. As a general rule, the dissolved solids content increases with depth. The chemical makeup is a direct reflection of the geological materials the water passes through, as is the evolution of its chemistry. Processes that control and may alter concentrations of solutes are: cation exchange reactions, complexing (chelation) reactions of metal ions with organic groups, specific adsorption of metal ions on mineral surfaces, specific adsorption of anions on mineral surfaces, adsorption of organic compounds, precipitation reactions, oxidation-reduction reactions, and various biochemical reactions. Most of these reactions are strongly influenced by the acidity (pH) of both the solute and the soil and sediment environment. For a more detailed review the interested reader is referred to Freeze and Cherry, 1979; Lindsay, 1979; Stumm and Morgan, 1970; and Tinsley, 1979. From the foregoing it is obvious that precipitation infiltrating into the ground enters a highly complex chemical environment, which will modify its original composition.

Use determines what standards will be applied to water quality. Different guidelines for water quality have been established for drinking water, industrial use, recreational use, preservation of marine or freshwater bio-communities, etc. (McNeely et al., 1979). Inherent in this approach is the assumption that a certain level of contamination will inevitably be present. The degree of contamination considered acceptable is generally determined by a cost-benefit analysis of downstream use. This implies that, because of political considerations, only short-term socio-economic benefits to society will be weighed. Long-term preservation of the quality of the terrestrial environment, which includes both surface water and groundwater, for future generations is often based on the blind hope that dispersion and diffusion of contaminants will suffice to maintain that quality. It is true that the natural environment has a tremendous capacity to absorb contaminants. Geological and biochemical processes operating in the natural environment generate very large quantities of substances classified by man as contaminants, which do not appear to cause major changes in the ecosystem. However, according to Fyfe (1982), man has become the greatest agent in modifying the surface environmental systems. The contribution to metal loading of rivers, and thus also the oceans, by the activity of man in most instances is an order of magnitude greater than that produced by natural processes. This is illustrated in Table 1.

Table I. Natural and man-made fluxes of metals into oceans (x 10^3 tons/yr), after Barney (1980).

	Natural	By Man
Iron	25,000	319,000
Manganese	440	1,600
Copper	375	4,400
Zinc	370	3,930
Nickel	300	358
Lead	180	2,330
Molybdenum	13	57
Silver	5	7
Mercury	3	7
Tin	1.5	166
Antimony	1.3	40

The additional influx of metals created by the activities of man will undoubtedly result in an adjustment of the bio-community in the receiving natural subenvironment with time. Geological history provides vivid examples of this type of evolutionary change. It is unfortunate that there is no appreciation of the potential magnitude of the long-term consequences of present activities, especially when it is realized that the present is the key to the future quality of the environment.

4.2 Groundwater Contaminants and their Movement

Groundwater is considered polluted when it contains dissolved chemical constituents which exceed the quality criteria for a specific use. The sources of these dissolved constituents are natural processes and/or the activities of man. Common usage appears to reserve the noun "contaminant" for those substances introduced by man which are deleterious to the quality of the natural environment. This usage will be followed in this paper.

There are many examples of naturally polluted groundwater, only a few of which will be mentioned here to illustrate its presence. These are: excessive amounts of iron, aluminum, zinc, lead, and copper in the Paint Pots springs, Kootenay National Park (van Everdingen, 1972b); salt springs along the contact between the Canadian Shield and the Western Sedimentary Basin (van Everdingen, 1971; Weyer, 1983); natural discharge of crude oil in the Petrolia area, southern Ontario; arsenic and uranium in groundwater in Nova Scotia; seawater intrusion in coastal areas; high manganese and iron content in induced infiltration water as a result of buried logs in river channel deposits in New Brunswick. A detailed discussion of pollution of groundwater by the natural environment is beyond the scope of this paper.

Groundwater contamination caused by the activities of man is the result of direct introduction of contaminants, mechanical failure of structures, lack of understanding of the natural environment, the "out of sight, out of mind" syndrome, lack of monitoring, lack of enforcement of existing regulations, unrealistic expectations generated by model studies of natural environments, etc. These observations will be further explained in the following sections of this chapter.

From the description of aquifers it is apparent that unconfined aquifers are most susceptible,leaky confined aquifers less susceptible, and confined aquifers least susceptible to groundwater contamination by direct introduction of pollutants to the subsurface environment. Furthermore, if the various geological environments are considered, fractured rock and sediment environments and those with secondary solution openings (karstic carbonates) are more readily contaminated than the environments with intergranular flow. Under the same hydrogeological conditions of head distribution, infiltration of contaminants as well as their lateral movement will be much faster in the former geological environments.

Contaminants are subjected to the same processes and reactions that affect the natural evolution of the groundwater chemistry, However, the reactivity of sedimentary environments with intergranular flow is much greater than that of fractured and karstic environments. This is due in part to the much greater surface area in contact with flowing groundwater and its dissolved constituents, and in part to the mineralogy of the sediments. All sedimentary deposits contain clays in various degrees of abundance, which are much more surface-active than, for example, the weathering products on fracture faces in fractured rock environments or on the surface of carbonates in solution channels. Attenuation of chemical constituents by the environment therefore plays a much more prominent role in sedimentary environments with intergranular flow than in the other geological environments. This also means that a sedimentary environment will show a residual contaminant concentration

much longer, after the main contaminant "plume" has moved through, than the other environments. An analogy may be drawn with, for example, the recovery of crude oil, where the primary recovery from limestone reservoirs is generally about twice as high as that from sandstone reservoirs.

The various ways in which contaminants can be introduced into groundwater are shown in Figure 15. It is obvious from this figure that a large number of possibilities for contamination exist. Miscible contaminants will be incorporated in a groundwater flow system and will move away from their point of entry under the same natural laws that govern groundwater flow. Immiscible liquids will move down to the water-table and spread on top of the watertable in the direction of its slope (Fig. 16).

The rate of movement of a miscible contaminant is identical to the rate of flow of groundwater. However, the distance a contaminant travels is a function of the degree of its attenuation. The overall effect is an apparently slower rate of travel. Contaminants will follow the same paths as the groundwater. This is illustrated in Figure 17, which is similar to Figure 4. The situations depicted in Figures 17a, b, c, and d are very common in the natural environment, both on a micro- and on a macro-scale, and especially in the more recent Pleistocene and Holocene sediments, which form the surficial cover over most of Canada. The rate of attenuation will be greatest in slightly permeable sediments (low K-values). However, in these sediments flow is essentially vertical and the distance of travel is generally short. Horizontal travel occurs primarily in the more permeably beds, where the degree of attenuation will be considerably less. Figure 17c shows a classic example of a stratigraphic trap. Contaminants that are retarded by

attenuation, hydrocarbons for example, would tend to accumulate at the contact between the high and low permeability beds, i.e. in the area where the highly pemeable bed stops. The greater the permeability contrast between the beds, the more effective the trap will be. However, as the flow lines indicate, flow is not stopped by these stratigraphic features, but continues. The effectiveness of the trap depends therefore on the chemical properties of the contaminant, the physico-chemical properties of the geological environment, and their interaction.

The foregoing examples also illustrate that the flow of water and the concomitant flow of contaminants in a heterogeneous geological environment will be concentrated in the most permeable beds. Dispersion and diffusion are generally restricted to a narrow zone around the contaminated body. The distribution of the contaminants in the subsurface generally reflects the (usually nonhomogeneous) permeability distribution. The widely accepted practice of representing contaminant fronts as large bodies spreading and dispersing uniformly through a geological environment is totally without foundation and shows a lack of understanding of the geological environment, and a lack of understanding of the limitations of data collection methods which are inherent in, for example, the type of drilling equipment used, the type and construction methods of sampling points, etc., or are due to insufficient quantity and quality of the data.

Without a proper definition of the hydrogeological environment, contaminant movement studies, computer modeling, and the design of remedial measures are analogous to a game of Russian Roulette.

As was mentioned before, groundwater flow will occur in time in all

sediments and rocks. No sediment or rock is impermeable on a geological time scale. Impermeability is a concept created by man because of an inability to grasp the effect of time over any period longer than his own existence. The concept of impermeability or the notion of "for all practical purposes impermeable" is being applied extensively in waste management, especially in the case of land disposal sites. Although the actual permeability measurements on samples may indicate extremely low values, these values do not take into account the possible presence of root canals, desiccation cracks, fracturing, etc. The significance of these features should not be ignored, because they provide the primary escape routes for contaminants from a disposal basin. This is illustrated in the following examples.

Several years ago, a major mining company installed, with great care and at a considerable cost, a polyethylene membrane in a waste disposal basin, several hundred acres in size, to make it impermeable. But, as one of the engineers pointed out, complete integrity of the liner could not be guaranteed, because there would undoubtedly be a few pinholes. He estimated that the loss of liquid waste through one pinhole, 3 mm (1/8 inch) in diameter, depending on the liquid level in the basin, could amount to several thousand gallons per year. After the basin was operated for a few years, his predictions were proven correct: significant groundwater pollution did indeed occur.

Many shallow confined aquifers show a low barometric efficiency. Barometric efficiency is a measure of the response of the water level in a well to changes in the barometric pressure (Jacob, 1940). For truly elastic, homogeneous, confined aquifers the barometric response would be 100

percent. However, if the aquifer is semi-confined, in other words if the "confining" beds are leaky, barometric efficiency values are considerably lower than 100 percent (Gilliland, 1969). The writer found values ranging from 9-32 percent in a so-called confined aquifer located at a depth of 10 metres (Vonhof, 1983). The "confining" layer was till. According to Grisak and Cherry (1975), the intergranular permeability of till based on a large number of core samples ($<$ 20 cm in diameter) is 5 x 10^{-9} cm/sec, i.e. for all practical purposes impermeable. This value falls well within the range of the permeability of clay (Freeze and Cherry, 1979). An examination of borrow pits in the area investigated by the writer showed that the till was fractured (Vonhof, 1983), which meant that the permeability of the till was several orders of magnitude greater than the above mentioned value. This would also explain the "leaky" character of the confining layer as indicated by the low barometric efficiency. Brine stored in a waste disposal basin located on top of the (leaky) till has in the meantime entered the underlying aquifer.

The above two examples are given to show the relativity of the term "impermeable" in waste disposal basins. In the first case a concerted effort was made to make the basin impermeable, whereas in the second case the values derived from measurements of intergranular permeability were considered in isolation from other features of the sediment. The end result in both cases was significant groundwater contamination. Experience indicates that these examples are not isolated cases; unfortunately, they appear to be the rule rather than the exception. Adherence to the concept of impermeability will guarantee major environmental problems for future generations.

It should be realized that storage in the surface environment, of liquid waste or of solid waste not properly protected from the elements, only delays its re-entry into another part of the natural environment.

Many instances of groundwater contamination from waste disposal in Canada are the result of past activities. Present environmental laws and regulations in most provinces are such that groundwater pollution can be prevented, or at least restricted to the immediate area of a disposal site, if waste disposal basins are monitored properly and if the regulations are indeed enforced. In the writer's experience, most industries are good corporate citizens and generally comply with the level of effort required by government. However, in addition to point-source contamination by liquid and solid wastes there is a continuous, diffuse input of chemicals introduced by agricultural practices and acid rain, which has the potential to cause large-scale contamination of groundwater with time.

In the following sections groundwater contamination from a number of sources will be discussed. This is by no means a detailed discussion, but an overview only.

4.3 Mining

Mining, like any other activity of man, causes environmental contamination. To require zero effect would be totally unrealistic and would render all mining operations uneconomical. However, by proper management the degree of contamination can be significantly limited without seriously affecting the economic viability of the operation. A somewhat greater

degree of freedom for environmental management exists in the mining industry as compared to other industries, because many mines are located in remote parts of the country with few, if any, other users of the same environment. Also, general background levels of the particular commodity mined are in several cases already considerable in the natural environment where the mine is located. This phenomenon, in fact, is the basis for the geochemical exploration techniques used by mining companies.

The main sources of environmental contaminants in mining operations are atmospheric emissions, mine drainage, tailings disposal, discharge water from the extraction phase, and discharge water from the beneficiation phase. Although atmospheric emissions are not a direct cause of groundwater contamination, they do represent a potential source after deposition on the land surface, either as particulate matter or incorporated in precipitation. The composition of the emitted particles and gaseous material will vary depending on the type of ore mined and the processing method employed. The emissions will result in elevated levels of various metals in the soil and acid rain.

The total land area disturbed and utilized by the metallic and non-metallic mineral sectors (excluding construction materials) is about 112,260 hectares. Smelter and refinery operations located on industrial sites within urban centres utilize an additional 7,670 hectares (Marshall, 1982). It is estimated that in the next twenty years and additional area of approximately 60,000 hectares will be disturbed by the mineral sector. In addition, the energy-related sector of mining has affected about 34,000 hectares of land. A projected three-fold increase in surface mined coal over

the next twenty years will result in an additional land disturbance of between 18,000 to 20,000 hectares (Marshall, 1982). Part of the land disturbed by mining will be reclaimed. In addition to the land directly disturbed by the mining operation, mining can also have a considerable influence on the land surrounding its operation. This influence is referred to as the "shadow effect" (Marshall, 1983). It would include lands affected by atmospheric emissions and the area affected by contamination of both surface and groundwater. The size of the area thus affected may be many times greater than the actual mine site or lands within the operational control of the mine.

In 1980 (E.M.R., 1981) the total volumes of ore mined and waste generated were 290 x 10^6 tonnes and 445 x 10^6 tonnes respectively.

Metal mining. The main environmental concern of metal mining and milling operations is the accelerated introduction of metals into the environment. Contaminated water from mining activities is primarily associated with mine drainage, leachate from tailing storage areas, mill water, and waste solutions released in the hydro and electro-metallurgial processes.

Mining increases the surface area of rock. This in turn results in increased exposure of minerals to oxidation. Bringing sulphide minerals into contact with water and air promotes a chemical reaction which results in the formation of sulphuric acid, which in turn will increase the dissolution rate of metals and hence their mobility in the environment. Note: not all mines have acid mine drainage problems; in Canada such problems are normally only associated with sulphide-bearing metallic ores (Marshall, 1982).

Introduction of specific species of bacteria to extract metals from low-grade ore is a promising technique and is used successfully at a number

of mine sites. The main group of bacteria used is Thiobacillus ferrooxidans. It uses sulphur and iron in the presence of water and oxygen in its metabolic system to extract energy, and it creates sulphuric acid as a waste product, which in turn dissolves other more valuable metal sulphides. However, the environment of these bacteria is not restricted to ore zones. As a result, other parts of the mine, as well as tailing piles that contain iron sulphides, can be infected.

The mine drainage water which often contains significant quantities of toxic dissolved metals is stored at surface in ponds. Part of this water may be recycled for use in the mining operation. Prior to the release of the effluent water to the environment the water is treated to neutralize the acids, remove heavy metals, and radioactive substances where present. Losses of water from impoundment areas occur as a result of evaporation, runoff, seepage, and percolation.

Beneficiation of ores results in additional potential contaminants, created by the mining industry, which have to be isolated in the environment. Mill tailings, generally very finely ground material, together with effluent water from the mill is disposed of in impoundment areas. The slurry invariably contains a small percentage of the constituents of the original ore and small quantities of organic reagents used in the mineral processing. The reagents include frothers, collectors, depressants, pH modifiers, activating agents, flocculants, coagulants, and dispersants (Marshall, 1982). Although recycling of effluent water has drastically reduced the volume to be disposed of, most water is eventually discharged to impoundment areas. Many reagents are highly toxic and lethal to some organisms (Hawley, 1977).

Waste disposal practices, properly managed and enforced at existing mining and milling operations, generally do not present a major threat to the environment over the lifetime of their operation. Problems do, however, occur after the mine or mill has been abandoned and in areas where mining activity was started prior to the passing of the environmental regulations by the various levels of government. In many of the older mining districts in Canada tailings and effluents were dumped in areas of convenience rather than in environmentally safe areas. Furthermore, bacterial growth, oxidation, infiltration of precipitation, geochemical processes, and groundwater flow in abandoned mines and tailing piles and ponds continue and these have led to serious problems of contamination. Ample evidence of this is available in all old mining districts in Canada. In most instances where problem areas have been recognized only the contamination of the surface water environment has been documented, for example Giant Yellowknife, Cominco Con, Echo Bay, and Canada Tungsten mines in the Northwest Territories (Wallace et al., 1975); the Flin Flon area, Manitoba (Rowley, 1975); and Serpent River Basin, Ontario (Roy & Keller, 1976). An example of a case where groundwater contamination is suspected but has not been documented is the Canada Tungsten mine in the Northwest Territories (Wallace et al., 1975). Overflow from the tailings pond was discharged into a gravel pit. Wallace et al. (1975) report that "Due to the porosity of the bottom and sides of the gravel pit, the fluid was lost to the water table and could not be visibly traced".

Examples of serious acid mine drainage problems caused by uncontrolled bacterial growth and tailings pile infestation can be found at the Britannia Beach mine and the Equity silver mine, respectively, in British Columbia

(The Calgary Herald, December 5, 1984). Millions of dollars are being spent at the Equity silver mine to correct the bacterial infections, which unfortunately are very difficult to kill. Furthermore, the compounds used to combat these infections are highly toxic to the environment and could thus present an additional problem.

The aspect of groundwater contamination near mining operations has, based on a survey of the published literature, received little attention in Canada. It is nevertheless reasonable to assume that groundwater contamination is occurring in all mining districts where tailings and effluent water were disposed of in an environmentally uncontrolled fashion. Lack of data precludes any estimate of the extent and degree of groundwater contamination in the mining districts. Similarly, the long-term effect of groundwater contamination on the surface water resources in a given area is difficult to assess, especially if it is considered that the natural subsurface environment has a large capacity to attenuate several metals and other dissolved chemical compounds.

Reclamation of abandoned mine and mill sites in the older, but still operating, mining districts in Canada is going to require hundreds of millions of dollars. Today reclamation is considered an essential part of resource management and regulations and policies covering this aspect in one form or another exist in all provinces. A number of joint work groups of representatives from various levels of government have been created to examine different aspects of land reclamation.

A backlog of several tens of thousands of hectares of land disturbed by mining exists across Canada. In many instances, funding to investigate and

assess the extent of environmental damage, both in terms of the surface and the subsurface environment, and to cover the cost of reclamation will have to be provided by governments, either provincial, federal, or both. This is necessary, because unfortunately in a large number of cases the companies that conducted the mining and milling operations which caused the current problems no longer exist. In several provinces, for example Ontario and Quebec, environmental management of abandoned mine sites has therefore been taken over by the government. The long-term implications of mine waste will be addressed further in another part of this paper.

Coal mining. Coal mines differ from metal mines in that the direct introduction of metals into the environment is usually negligible. This does not mean that coal does not contain metals; on the contrary, coals are known to contain a very large number of metals in varying concentrations. These are released during burning. A portion of the metals is trapped in fly ash, the remainder enters the atmosphere and returns to the surface by fallout.

Most coal contains sulphur, from a fraction of a percent to several

percent. Oxidation or bacterial conversion of the sulfur can cause acid mine drainage problems. The severity of such problems depends on the longterm buffering capacity of the environment.

Coal, like other minerals, may be mined by open-pit or underground methods. In open-pit mining the sediment between the zone of interest and the surface is removed. This often results in the physical destruction of aquifers. Unlike to open-pit metal mines, most open-pit coal mines are filled in and the land reclaimed. Although it is theoretically possible to reconstruct the aquifers, cost-benefit analysis will show that it is invariably uneconomical to do this. Backfilled open pits therefore act as a facies change in the lateral continuity of sedimentary beds. Since the fill is heterogeneous, the possibility of cross-formational flow between aquifers exists. Depending on the chemical composition of the waters and the resultant direction of flow, this may be beneficial or detrimental. Also, the fill generally contains a higher percentage of soluble material than the original aquifers, which can result in an increase in the dissolved ion content of the groundwater with time (Moran and Cherry, 1977).

Underground coal mines as a rule are not backfilled. After mining the roof is allowed to collapse. This will cause fracturing of the overlying beds and changes in groundwater flow patterns in the area, which could result in increases in mine drainage. If the water is oxygenated, this will result in accelerated oxidation of sulphur compounds. After abandonment the problems of acid mine drainage can be similar to those in metal mines.

Where large quantities of ammonium nitrate-based explosives are used,

contamination of the environment by these compounds can also occur (Weyer and Vonhof, 1980). It appears that the longterm environmental effects of (reclaimed) open-pit mines are less than those of underground coal mines.

Potash mining. Potash is being mined in Saskatchewan and in New Brunswick. Both liquid and solid granular wastes are generated (Vonhof, 1983). The waste, sodium chloride, is generally stored in waste disposal basins. At most mines in Saskatchewan part of the liquid waste is disposed of by deep-well injection, whereas a pipeline to the Atlantic ocean is being planned for the mines in New Brunswick. The solid waste is generally stacked, forming some of the more significant topographic features in Saskatchewan. The combined area of the waste disposal basins in Saskatchewan is approximately 35 km^2, containing about 200-300 million tons of sodium chloride and growing daily.

Brine has infiltrated the subsurface at every disposal basin and this has resulted in local groundwater contamination. To limit the spread of groundwater contamination, which at a number of mines could also result in contamination of major freshwater aquifers or surface water resources, slurry cutoff walls had to be installed.

Originally it was thought that the solid waste could be returned underground in the rooms left behind by mining. However, the mined areas close slowly with time due to the viscous flow behaviour of salt (Baar, 1977).

If granular salt is piled high enough, recrystallization will occur at the bottom. Once the bottom layer is recrystallized, it becomes essentially an impermeable layer, thus preventing further groundwater flow into the underlying sediment. It was hoped that by stacking the waste salt this

condition could be achieved in Saskatchewan. According to Maathuis (personal communication, 1985), a height of 50 metres may be required. Even if this phenomenon did occur, observations by the writer and others (Maathuis, van der Kamp, personal communication, 1985) show that the salt is rife with solution channels. This is due in part to the method of waste discharge into the basin and in part to the fact that precipitation causes solution karst. Furthermore, the fine-grained sediments that underly the waste salt are subjected to compaction by the loading of the waste salt pile. "Fresh" water expelled during this process will dissolve salt at the base of the pile (Maathuis and van der Kamp, 1983).

The total volume of brine produced per year by the petroleum industry in western Canada is comparable to the waste salt production of the potash industry (Zenon, 1983). However, the petroleum industry is not allowed to dispose of any of its brine in the surface environment.

4.4 Oil and Refined Petroleum Products

The potential impact on the environment of onshore Canadian oil and gas drilling and production was recently reviewed by Zenon (1983). Drilling and primary production generally have a low level of impact except when a major blowout occurs, as recently happened at the Amoco sour gas well near Drayton Valley, Alberta. Brine contamination of the shallow subsurface is a problem at some of the old battery sites, but this is generally due to the operating practices prevailing at the time, when environmental regulations were not as strict (de Jong, 1980). Prior to abandonment of a site, industry has to clean up

before approval is given by the regulatory agencies in the producing provinces.

Of greater concern are the potential problems that can arise from enhanced oil recovery projects. In enhanced recovery, special techniques are used to recover the oil left in place after primary and secondary recovery have become uneconomical. Methods used are chemical, thermal, and miscible flooding. The waste products generated during miscible flooding are in general similar to those of conventional oil production and their environmental impact is low under normal and proven operating practices. The most serious waste problems appear to be connected with chemical flooding, because of the toxicity of the chemicals used (Zenon, 1983). However, this process is still in th experimental stage. Thermal flooding is used extensively in the recovery of heavy oil. There are a number of problems associated with heavy-oil production. These are:

- Sand production. This ranges from 0.5 to 10 percent of the volume of oil produced. The sand will be coated with a thin film of oil or solvent if a further recovery of oil is attempted. The sand is presently used in road paving, but it is expected that with large-scale development of heavy oil fields the sand will have to be stored, which could lead to groundwater contamination. Proper placement in the hydrogeological environment therefore becomes very important to minimize migration of contaminants.
- Subsidence. As a result of the removal of large quantities of sand, subsidence can occur around a well head, which in turn may affect the integrity of the well bore and/or the confining beds. This could

lead to cross-formational flow and contamination.

- Liquid waste. The water produced with the oil and during the upgrading of the oil cannot be discharged to the environment. Present plans are to re-use part of the water and dispose of the remainder by deep-well injection. Whatever is injected in northeastern Alberta and the adjoining area in Saskatchewan will flow in a northeasterly direction, following the regional direction of groundwater flow. Liquid waste injected in Alberta will ultimately end up in Saskatchewan. Although a three-dimensional groundwater flow model for the Cold Lake area has been developed by the Alberta Research Council in cooperation with Esso Resources, the study was concerned only with local effects and did not address inter-provincial effects.

In addition to deep-well disposal, some of the liquid waste, for example sludges, will be disposed of in ponds. It is difficult to assess the potential impact of the various liquid wastes, because little is known about their composition, volume, and toxicity, and further studies will have to be undertaken.

The impact of gas processing plants on the environment is presently undergoing intensive review in Alberta. New regulations governing all aspects of the environment are expected there in the near future.

Spills of refined petroleum products, such as aviation fuel, gasoline, diesel fuel, etc., caused by spillage, breaks in pipelines, or leakage from underground tanks, generally receive the greatest amount of attention. Infiltration of petroleum products into the shallow subsurface and their subsequent movement can result in groundwater pollution, explosions, fire

hazards, and health hazards (Vonhof, 1977). The effects can be local or widespread. The worst case in Canada occurred in St. Eustache, Quebec in 1978. Gasoline leaking from an underground tank spread over a large area, seeped into sewage lines and resulted in explosions. More than 2000 people had to be evacuated and the total cost of evacuation, cleanup, and rehabilitation was well in excess of one million dollars.

In most cases, fire and explosion hazards are the primary concern. However, in areas where groundwater is an important resource, a petroleum-product spill can be devastating. One litre of gasoline can easily contaminate one million litres of drinking water. Treatment procedures are available, but costly. In Europe, where 75 percent of the population relies on groundwater, contamination by petroleum products is considered very serious; and spills generally result in immediate action by government.

Petroleum products, once incorporated in the subsurface and in the groundwater flow system, are extremely difficult to remove. Whatever in-situ method is used for cleanup, there will always be a residual component. The volume of the residue is a function of the geological environment, and will be much greater in sedimentary deposits than in fractured rock or sediments with secondary solution openings. Primary recovery in sedimentary deposits is generally in the order of 30-50 percent, and may be considerably higher in the other environments. The residual concentration can contribute to groundwater pollution for a long time. There are documented cases in Europe where petroleum products have been a source of groundwater contamination for more than 50 years (Zimmermann, 1967). Cleanup measures are invariably long term and costly procedures. Governments that have recognized this fact and

also understand that contamination of groundwater not only destroys a vital freshwater resource,but will inevitably lead to a reduction of surface-water quality, have put their main emphasis on preventive measures to avoid groundwater contamination. For example, mandatory testing of both private and commercial storage tanks, on a regular basis, is common in many countries in Europe. Inventory control is strict, and abnormalities are to be reported to the authorities immediately. Cathodic protection is mandatory in many areas; vaults are used in groundwater sensitive areas, etc.

In Canada, company owned distribution centres and service stations are generally well managed. Most problems occur at owner-operated stations. Although inventory control is required by regulation by several provincial governments or by companies supplying products, and although it certainly should be practiced by the owners for reasons of good housekeeping, it is generally not actively enforced. Inventory discrepancies are almost always discovered after a major problem surfaces. In many instances the financial resources of the owner-operator are limited. This means that a third party, generally the government, has to first assume the cost of any investigation and remedial measures, with the hope of recovering some of the costs later. Damages incurred by other parties may or may not be recoverable at all.

In most instances, underground leaks are caused by corrosion of unprotected storage tanks. It was estimated in the late seventies that 48,000 unprotected buried tanks were present in Ontario alone (Canadian Water Well, 1985) The total number of unprotected tanks in Canada is not known, but it is estimated to be well in excess of 100,000. Although replacement programs are in effect in many provinces,it appears from the numbers involved that a considerable number of underground leaks will still occur in the foreseeable future.

4.5 Industrial Sources and Landfills

Groundwater contamination caused by various industries other than those described above is difficult to define, because potential contaminants are often unique to the type of industry and their effects on the subsurface environment are site-specific.

Many industries discharge their waste to municipal sewer systems where, after treatment, it is released to the surface environment or is concentrated in sewage sludge. Sludge is generally disposed of by land spreading. Sludge is a valuable source of nitrogen and phosphorous, but it generally also contains a host of heavy metals and occasionally toxic organic compounds. Metals which commonly occur in sludge are cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, selenium, silver, tin, and zinc. The sources of these metals are domestic and industrial sewage and storm runoff. The metals are retained by the soil after sludge application. Repeated application of sludge will lead to an incremental build-up of these metals in the soil. Uptake of part of the metals by plants can make the plants toxic to livestock and humans or, where excessive concentrations of the metals are present in the soil, the soil itself may become toxic to plants (Bates, 1972).

Soil contamination by metals and other chemicals is not restricted to sludge application. Industrial smoke stacks, vehicle exhaust, dust particles, etc. all represent potential sources. For example, elevated levels of nickel, copper, and zinc were found in soil downwind from nickel smelting operations at Coniston, Ontario (Rutherford & Bray, 1979); fluorine levels increased downwind from aluminum smelters in the St. Laurence valley, Cornwall, Ontario,

and the Lac Saint Jean region, Quebec (Simpson Lewis et al., 1983); and increased sodium and potassium levels are found in the soil downwind of the potash mines in Saskatchewan.

The extent to which groundwater may become contaminated with heavy metals from sludge applied to soil is dependent on the heavy metal content of the applied sludge, the loading rate, the physico-chemical properties of the soil, the texture of the soil, the distance to the water table, and the precipitation rate. Most metals appear to be fixed by the soil and thus become immobilized. The threat of groundwater contamination therefore appears to be minimal. However, continuing input of acid precipitation may alter the present equilibrium and remobilize those metals. The total area which receives sewage sludge in Canada is not known, but Ontario alone uses approximately 11,000 hectares (Simpson Lewis et al., 1983).

Landfills, although primarily designed to receive domestic garbage, also receive a considerable amount of industrial waste and are therefore included in this chapter.

The total amount of garbage generated in Canada is about 15×10^6 tonnes per year. Toronto alone produces approximately 1.4×10^6 tonnes per year, which would cover a land area of 40 hectares with a 3 metre thick layer (McKechnie et al., 1983).

Leachate produced in the landfills is the main environmental concern. Runoff from landfill sites or infiltration of leachate into the shallow subsurface can seriously affect the quality of the receiving water. Leachate is produced by the decomposition of organic compounds and as a result of direct introduction of water which dissolves soluble matter. Water enters

landfills as precipitation, groundwater inflow, surface seepage and runoff from surrounding land.

The composition of the leachate is controlled by the types of waste deposited. Decomposition of ordinary municipal waste produces methane, carbon dioxide, water, various organic acids, nitrates, chlorides, calcium, manganese, iron, ammonia, etc. In ordinary municipal waste the leachate strength is attributed to textiles, rubber, leather, wood, paper, and cardboard (McKechnie et al., 1983). All landfills receive a certain percentage of hazardous waste from regular household use (solvents, cleaners, metals, etc.). It appears, however, that the diffuse distribution of this material within the landfill does not present a serious problem.

In properly managed landfill operations leachate production is kept to a minimum. This is achieved by proper siting of the disposal area in the hydrogeological environment, modification of the surface runoff pattern, and elimination of infiltration of precipitation. The latter is achieved by placing clay caps on the refuse shortly after the waste has been deposited. Furthermore, operational practices in present-day landfills tend to isolate volumes of refuse in separate cells and the waste in each cell is bounded on all sides by clay or clay-rich sediment.

In hydrogeological settings where leachate is expected to be a problem, contamination of the groundwater can be limited by the installation of drains, cut-off trenches, and pumping wells. The leachate recovered will have to be treated prior to discharge into the surface environment.

In the past, hazardous wastes were indiscriminately dumped in landfill sites across the country without any regard to the environment in which the site was situated. Furthermore, many landfill sites were located in abandoned

gravel and sand pits, rock quarries, and convenient natural depressions, such as gullies, sloughs, coulees, swamps, etc. Examples of this type of disposal can be found in the countryside in all provinces and territories.

One of the worst cases of contamination of groundwater by industrial waste has occurred in the region of Mercier, Quebec (Poulin et al., 1984). About 40,000 m^3 of liquid wastes from chemical and petrochemical industries in the Montreal area were disposed of in a gravel pit. This has resulted in groundwater contamination over an area of 30 km^2. The main contaminants are chloroform, dichloroethylene, trichloroethylene, dichloroethane, trichloroethane, chlorobenzene, phenols, and BPC (arochlor 1254 and 1260). It is expected that it will cost the Quebec government in excess of 10 million dollars to recover and treat the waste and provide water from another source for the inhabitants of the region.

Under current environmental legislation in the various provinces, new landfill sites and industrial waste disposal areas require a definition of the hydrogeological environment, monitoring programs, and, where necessary, installation of impermeable membranes or clay layers and drainage systems.

All provinces have embarked on waste-site identification programs and risk assessment of the sites of old waste disposal locations and landfills. Criteria used in the risk assessment include type of waste disposed of, physical setting with respect to surface drainage, and location within the hydrogeological environment. The surveys are at this point in time at various levels of completeness, both in terms of inventory (abandoned landfills, active landfills, or both, or all waste disposal sites) and the level of information on each site. For example, Ontario has identified approximately

1400 sites which were closed before 1971. Of these, 197 with the greatest potential for environmental impact were studied in more detail. In only three cases were off-site impacts observed. Currently the active landfill sites are being evaluated. Four hundred waste disposal sites have been identified in Prince Edward Island. Based on a priority rating, 22 sites were investigated in detail. No off-site impacts were observed. In Quebec a detailed survey of waste disposal sites has been completed. The type of waste as well as potential impact on the groundwater and surface water resources has been identified. Further investigations will be conducted around these sites to determine the extent and degree of groundwater contamination. In an area with a radius of approximately 35 km around Montreal, 50 sites were identified. One of these sites, at Mercier, was discussed previously. Saskatchewan has inventoried all its abandoned and active landfill sites, but hydrogeological investigations have only just commenced. In Alberta all landfill sites have been identified and rated with respect to their potential effect on the environment. Hydrogeological investigations have been conducted at several sites. Leachate problems have been detected at a number of these.

Most provinces have designated portions of existing landfill sites to handle hazardous toxic wastes, or they are planning special landfill sites which can accept this type of waste either in storage or for further processing to render it harmless (Alberta, Ontario, and Quebec). The Alberta facility will be located in the Swan Hills and will include a deep well disposal system. In most instances, the special landfill sites will be operated by crown corporations.

From the foregoing it is obvious that it is not possible at this time

to assess the environmental impact of all the old industrial waste-disposal sites and abandoned landfills in Canada, because the data base is insufficient and incomplete. No cost estimates of clean-up can be made at present.

Experience with the U.S. Superfund indicates that major remedial work will be necessary at more than 400 industrial waste-disposal locations. At about 25 percent of these sites, which are primarily chemical and petrochemical waste dumps, expenditures will be in excess of 1 million dollars. Ontario has estimated, based on proportionality of population between the U.S. and Canada, that about 19 million dollars would be required in that province alone MOE, 1984). For Canada as a whole this would mean a total in the order of 60 million dollars. If it is considered that the clean-up bill of the Mercier site in Quebec is 10 million dollars (minimum), and estimates of individual sites in the U.S. are several tens of millions of dollars, it appears that the Ontario estimate is optimistically low. To generate sufficient funds for clean-up of abandoned waste disposal sites, Ontario is considering the creation of a waste management security fund. The fund would be built up by a surcharge on disposal fees at approved waste management facilities. In addition, the government of Ontario is considering to require operators and owners of waste management facilities to carry environmental impairment insurance and/or the posting of financial guarantees (MOE, 1984). The approach suggested by Ontario operates on a "user pays" basis. The fund will be used to cover costs of environmental emergencies at active disposal sites, provide funds for perpetual care of toxic waste, and moneys to clean-up abandoned sites. It is expected that the other provinces will follow a similar approach for their waste management.

4.6 Agriculture

Sources of groundwater contamination by the agricultural industry include animal feedlots, manure piles, pesticide, fuel and fertilizer storage, and land application of fertilizers and pesticides. In addition, dryland crop-fallow rotation practices can cause significant changes in the water quality of aquifers.

Animal feedlots, manure piles, and leaking septic tanks can cause significant groundwater contamination problems by introducing nitrate, chloride, organic carbon,and ammonia, as well as bacteria and viruses. Although attenuation of the carbon, ammonia, and bacteria concentrations does take place in the unsaturated section of the soil, overloading will result in downward movement.

Groundwater contamination as a result of storage of pesticides or fertilizer is usually primarily due to poor site selection and poor house-keeping practices, but can also be the result of an unforeseen accident. An example of the latter occurred recently in Prince Edward Island: during a fire in a storage shed a considerable quantity of pesticides was dissolved during attempts to extinguish the fire. This resulted in local contamination of the subsurface.

If application of highly soluble (nitrate) fertilizers takes place under unfavourable soil conditions, i.e. light-textures soils with high infiltration capacity, contamination of the groundwater in water-table aquifers will take place. However, it has been found that, if the water-table is shallow and downward transport of organic carbon (which causes a reduction of dissolved oxygen in the water) takes place, denitrification of the nitrate by anaerobic

bacteria occurs in the aquifer (Hendry et al., 1983; Gilham et al., 1984). This process results in a significant reduction of the nitrate content in the aquifer where the water-table is shallow. In parts of the aquifer with a relatively deep water-table little or no denitrification occurs (Gilham et al., 1984). Another process that can cause high nitrate concentrations in water-table or unconfined aquifers is oxidation of organic nitrogen (Kreitler & Jones, 1975). However, this only occurs in areas where plants are grown that fix nitrogen.

In many parts of southern Alberta very high nitrate concentrations have been found in the shallow subsurface. The distribution of areas with high nitrate is restricted to oxidized tills. Studies conducted by Hendry et al. (1984) show that this nitrate originates from aerobic bacterial processes, which convert exchangeable NH_3 present in the unoxidized till. It appears that NH_3 is indigenous to the sediment. If this is true, then it is possible that many areas of the Prairies could have similar nitrate contamination of the shallow subsurface.

Pesticides are used extensively by the agricultural industry. They comprise a group of chemicals highly toxic to man and their use is therefore relatively strictly controlled. However, it proved to be very difficult to obtain data on the actual amount, type, and composition of pesticides used in the various provinces. New Brunswick is the only province which requires distributors to report this information on an annual basis (Shanks, 1983). The only other data available on province-wide use are the surveys conducted in Nova Scotia and Prince Edward Island by the Environmental Protection Service, Atlantic Region, Environment Canada. The report for Prince Edward

Island is available, whereas the report for Nova Scotia is still confidential. Total pesticide use in New Brunswick was about one million kilograms of active ingredients in 1983, including the amount of pesticide used in forest spraying. Prince Edward Island uses about 49,000 kg of active ingredients in its agriculture industry.

Until recently it was thought that pesticides do not form a potential source of groundwater contamination, because of their low solubility, stability, biodegradability, volatility, sorption, etc. However, recent analysis of groundwater in the shallow subsurface in various parts of the country (New Brunswick; Prince Edward Island; St.Laurence Lowlands, Quebec; southern Ontario; Osoyoos area, British Columbia) have shown the presence of pesticides. Pesticides with a relatively high solubility (greater than 30 mg/L) applied to soils with a low water adsorption capacity and a low organic content in areas with relatively large amounts of precipitation (greater than 25 cm/year) could become a source of groundwater contamination. Sandy soils with a low organic content and shallow water-table are prime candidates. This type of soil is present in all provinces. Therefore, although no data are available for the Prairies, it is likely that pesticides. because they are used extensively, may be found in the subsurface also in that part of the country, especially in irrigated areas.

Thus far only areas with the above-mentioned soil type have been investigated. No extensive research has been conducted in areas where soils developed on clayey sediments. It has always been assumed that, because downward movement of liquid is retarded by very low intergranular permeability of these sediments, there is enough time for break-down of the pesticides.

However, as was pointed out earlier, many of these sediments have secondary permeabilities (fractures, desiccation cracks, etc.) which are orders of magnitude larger than their intergranular permeability. It is therefore quite possible that pesticides have migrated downward also in these sediments.

Saline soils have developed during this century in many parts of the dryland farming areas of western Canada. It is estimated that about 2.5 million hectares of arable land in Alberta and Saskatchewan have thus far been lost to this process. In addition, another 100,000 hectares were lost to the same process in irrigation areas in southern Alberta.

Saline soils develop when the water balance of local groundwater flow systems is upset (Fig. 18). The flow systems have been in existence for a long time without causing any significant saline soil development prior to settlement, because the mixture of native plant species was such that it regulated the water balance (Van der Pluym et al., 1981). Destruction of the native vegetation cover, in combination with crop-fallow rotation practices instituted for moisture preservation for grain growing, is primarily responsible for the development of saline soils. During fallow years, water-tables rise due to lack of consumption by plants, and as a result more head is available for movement. This in turn results in the movement of greater volumes of water from the recharge to the discharge area. Along its path in the shallow subsurface, the groundwater dissolves soluble salts and the net effect is an increase in the total amount of dissolved salt transported to the discharge area. Evaporation and evapotranspiration in the discharge area increases the salt concentration in the soil. Where water supply aquifers are present along the flow path of the groundwater, significant increases in the total dissolved solids concentration, up to an order of magnitude, have been found (Van der

Pluym et al., 1981). In many places, the water quality has deteriorated to such an extent that it is toxic to animals, let alone humans.

Saline seep areas can be reduced by limiting the amount of water available for recharge. This can be achieved by changing cropping patterns and/or using high water-consuming plant species. To reclaim the salinized soils, subsurface drainage will have to be installed and appropriate chemical amendments added to the affected area for soil restoration. The mineralized water collected by the drains has to be stored in ponds. After dilution by spring runoff it can be used for irrigation, or discharge to the surface water system during high flow periods only. This will of course cause an increase in the total dissolved solids load of rivers, which in turn may lead to a gradual change in the water quality for downstream users, especially if reservoirs are present.

In areas under irrigation, saline soils can be reclaimed in the same manner. The discharge water from the drains can be returned to the irrigation canals, where it will be diluted and can be re-used, or it can be collected by a separate drain system and either stored or run directly into a stream or river. Whatever method is used, removal of soluble salts from one area will inevitably result in an increase in the salt load in another part of the environment. The long-term implications for downstream use should therefore be considered prior to the initiation of any of the above-mentioned schemes.

4.7 Acid Precipitation

Acid loading of the surface results from both dry and wet deposition. Dry deposition refers to adsorption of particulate and gaseous material on land and water surfaces, whereas wet deposition includes all contaminants reaching the earth's surface in precipitation. Although acid precipitation is not a direct cause of groundwater contamination, the long-term input into the terrestrial environment can lead to changes that are detrimental to the quality of groundwater. Acid precipitation occurs in all areas of Canada. It is concentrated in certain areas in the Maritimes, central Canada, and Alberta, due to industrial activity and/or atmospheric circulation patterns.

Acid loading of the surface can be rendered relatively harmless by neutralization in the soil-rock-water system. However, when the neutralization capacity of the system has been exhausted, a lowering of the pH will occur, which in turn will result in recharge of acidic water to the groundwater flow system. The prime neutralizing agent is calcium carbonate (limestone) and dissolved calcium carbonate and calcium bicarbonate. A number of other neutralization mechanisms exist which involve weathering of silicates and dissolution of metals (Last et al., 1980).

Groundwater recharge areas will be the first to show the effect from acid loading. The continuous downward movement of "acidic" water will deplete the neutralization capacity of the soil, sediment, and rock profile to ever greater depths. On the other hand, discharge areas with their continuous outflow of buffered groundwater will have a much greater neutralization

capacity and are therefore less affected by acid loading. Similarly, basic groundwater discharging into surface water bodies contributes to the neutralization of the acid input into the surface water (Bottomley et al., 1984). The beneficial effects of groundwater discharge will continue until the groundwater itself has become acidic. Once this condition has been reached, surface water bodies will deteriorate rapidly, because the surface water body receives direct input not only from acid loading but also from acidic groundwater discharge. This will have disastrous consequences for local ecosystems. The rate at which acidification of surface and groundwater will proceed depends on the neutralization capacity of the hydrogeological environment. In general terms, the areas most sensitive to acid loading are the Canadian Shield, portions of the Maritimes, and a small part of central Alberta.

A recent review of acid neutralization processes within soil-rock-water systems (Weyer, 1984) indicates that the increase in acidity can result in changes in the permeability of the soil, accelerated downward transport of nutrients, dissolution of heavy metals, changes in the soil biological communities, etc. With time, acid precipitation will cause a reduction in the fertility of the soil, an increase in the heavy metal content of the groundwater, and deterioration of the quality of surface waters.

Up until 1982 a total of at least 1660 scientific articles were published on various aspects of acid precipitation (Wiltshire & Evans, 1984). Judging by the number of papers dealing directly with groundwater (nine) it appears that the effect on the quality of groundwater has thus far not received enough attention.

In Canada, major studies on the effect of acid loading and on the neutralization capacity of the soil-rock-water system are being initiated. As part of the Long Range Transport of Acidic Pollutants (LRTAP) program of Environment Canada, the National Hydrology Research Institute has started a research program to improve the understanding of the physical and chemical processes which neutralize acid loading of the soil-rock-water system, with the ultimate goal to determine the acid neutralization capacity of the system in catchment basins (Weyer, 1984). The fieldwork for this study will be conducted in the Turkey Lakes Watershed in Ontario, which is located on the Canadian Shield. Another major study that has a groundwater component will be undertaken in Alberta. This study will be conducted by the Kananaskis Research Centre of the University of Calgary, and is jointly funded by the oil industry and the provincial government. The primary aim of this study is to determine the effects of atmospheric emissions resulting from oil and gas activity.

At present there is no data base in Canada which can be used to assess the impact of acid loading on the quality of the groundwater in the various parts of the country. Tens of years of monitoring well-defined hydrogeological environments will be required to obtain the necessary data.

V. THE ROLE OF GOVERNMENT IN GROUNDWATER CONTAMINATION

The protection of groundwater resources has, until about fifteen years ago, received a relatively low priority from most governments in Canada. In part this is due to the diffuse distribution of its users (primarily the rural population), and for another part it is due to a lack of appreciation of the significance of groundwater as a resource, its interaction with surface water, the inevitable time delay in contaminant movement inherent to groundwater flow, and the lack of understanding by the general public of groundwater flow. However, an increasing number of cases of groundwater contamination, the very high cost and low success rate of clean-up, and a greater general awareness by the general public of environmental issues have led to the realization that this resource needs as much, if not more, protection than other parts of the environment. This has resulted in new regulations for the protection of groundwater resources.

Groundwater, and thus also its protection, falls under provincial jurisdiction. The federal government has direct authority over navigable waters, interprovincial waters, oceans (within limits), Arctic waters, and unorganized northern waters in the Territories; through fisheries, it also has authority over the quality of water as related to fish life, shipping, energy development, and pest-control products. It has indirect authority over provincial waters where critical conditions require federal assistance (Canada Water Act) and over contaminants when health is being impaired. Jurisdictional problems between the federal and provincial governments are likely to arise where contaminated groundwater discharges into surface water

under federal jurisdiction. In order to protect or maintain the quality of surface water the federal government should know the quality of discharging groundwater. This means that the interactive groundwater-surface water system has to be defined in terms of both quantity and quality. However, under the present division of jurisdictional powers, the maintenance of groundwater quality is the responsibility of provincial governments, and the federal government has to rely on the cooperation of these governments to ensure that the quality and quantity of groundwater discharging into waters under its jurisdiction is maintained.

All provinces have installed networks of observation wells to monitor groundwater levels, but only in Saskatchewan and Alberta has there been a program to also monitor the long-term quality of groundwater in the major aquifer systems in a systematic way. Major inorganic ions and trace metals are being determined. In all other provinces, thus far, groundwater quality monitoring has been site specific, e.g. town water supplies or areas with localized contamination; or chemical compound specific, for example the pesticide aldicarb (New Brunswick, Nova Scotia, and Prince Edward Island). Alberta at present is the only province which is planning the installation of a network of observation wells in the major aquifers specifically designed for the long-term monitoring of organic compounds. Alberta is also planning to determine the age of the water in the major aquifer systems in order to establish the time interval for sampling and the spatial distribution of sampling points with respect to source inputs.

From the foregoing it is obvious that groundwater quality is still poorly defined in most of Canada, and that baseline data on the quality and

changes in quality of groundwater discharging to the major surface water systems are essentially lacking. It appears, therefore, that in order for the federal government to manage the environmental quality of the surface waters under its jurisdiction, it should institute programs in cooperation with the provinces to obtain the necessary data on both the quantity and quality of discharging groundwater. Furthermore, to protect the quality of groundwater, the federal government would have to strengthen the existing legislation concerning substances toxic to health, and regulate the complete cycle of production, transportation, use, and disposal.

Under present environmental regulations and policies enacted by both levels of government, waste disposal to the terrestrial environment should no longer cause groundwater contamination. However, regulations are no good unless they are properly enforced. Unlike American environmental legislation, which is relatively specific and detailed, Canadian environmental laws are more general and their enforcement depends in many instances on the discretion of government officials. It is therefore conceivable that a polluter can continue to contaminate at will until he is stopped by someone prepared to take action. For example, according to an article in the "Calgary Herald" (January 23, 1985), federal government agencies and crown corporations were responsible for 33 percent of about 700 fuel and chemical spills that occurred across the Northwest Territories in the last decade. Of all the spill incidents caused by government agencies and industry combined, less than one percent were taken to court under the numerous environmental laws and regulations. In Prince Edward Island, where almost all water used is groundwater and where the protection of this resource is vital, several

federal government buildings have had fuel tanks installed that are not corrosion-resistant. This is contrary to the federal government's own Environmental Protection Service Guidelines, which require such installation for all federal facilities. These examples illustrate that there is a need to strengthen environmental laws and remove discretion from enforcement.

Another aspect of the environmental protection of the quality of groundwater resources which has to be addressed is the "reasonable use" concept in groundwater management, suggested by the Ministry of the Environment in Ontario (MOE, 1984b). Under this concept the minister decides what constitutes "reasonable use" and potential use of groundwater in the case of land associated with or adjacent to waste disposal sites or contaminant spills. This decision will be made on a case-by-case basis, because the wide variation in the quality, quantity, and availability of groundwater makes a fixed-standard approach impractical (MOE, 1984b). The decision as to the "reasonable use" at a particular location shall be based on:

- the present use of groundwater,
- its potential use, and
- the amount and quality of groundwater that is available.

In most instances the present use will be taken as the reasonable use. Where there is no current use of groundwater, criteria will be established for the potential use. The determination of potential "reasonable use" of the groundwater will be based on the quantity and quality now present in the vicinity of a planned disposal site and the current use of the resource in the general area. In addition, planning agencies may provide input with respect to potential land use in the vicinity of a planned disposal site, as

this might affect the use of groundwater. Attenuation of contaminants by the subsurface environment is one of the most important design criteria for the disposal facilities. This implies that some contamination of the subsurface and limited movement of contaminants within the boundaries of the property containing the landfill site will be allowed. However, contaminant movement is not necessarily restricted to this property. Contaminants will be allowed to enter adjacent property as long as they do not interfere with the use of the soil and do not contaminate the groundwater to a degree which would impair its use. In the case where the groundwater under the adjacent property is presently of better quality than the Provincial Drinking Water Objectives, a lowering of this quality would be acceptable. On the other hand, in areas where the water quality is poorer than the objectives but nontheless used as a drinking water source, no further decrease in quality will be allowed. However, where good alternate supplies of water are available, either from surface water sources or municipal systems, aquifers containing water of poor quality (i.e. less than water quality objectives) can be designated as contaminant attenuation zones.

A number of comments can be made about this suggested approach to groundwater management.

- The concept of "reasonable use" is concerned only with the present and the immediately foreseeable future, but does not address long-term demographic and economic developments.

- The standards for the protection of the quality of groundwater are discretionary. It is true that a number of guidelines for decision-making are provided, but the status of present and potential use of the groundwater

resource under the land adjacent to a waste disposal facility can readily be changed. This can be done, for example, by providing water of equal or better quality from an alternate source to the present or potential users, or by rezoning the adjacent land for a different land use. In both instances the use status of the groundwater resource is changed to such an extent that quality maintenance is no longer necessary and it can therefore be allowed to deteriorate.

- Aquifers with groundwater of a quality better than the provincial drinking water quality guidelines are allowed to be contaminated to a certain degree. This implies that a little bit of contamination is all right, even though it diminishes the value of the resource. On the other hand, no special effort is made to improve the quality of groundwater in aquifers where it is below that specified in the guidelines, but which is nonetheless used in many areas. In other words: excellent quality does not have to be maintained and poor quality is acceptable as long as it does not deteriorate further.

- Inherent in the "reasonable use" concept is the fact that contamination of the shallow subsurface and/or portions of aquifers is allowed. The degree and extent of the contamination is determined by the attenuation capacity of the subsurface environment. In principle, the contamination should be restricted to the waste disposal property, but transboundary flow onto adjacent properties is permitted if the "reasonable use" is not affected. As was pointed out before, the quality criteria are discretionary and can be readily amended. Groundwater is part of the hydrologic cycle and, as was discussed earlier, it provides a significant contribution to the surface water resources. If surface water resources are to be protected because of their significant economic value as a source of fresh water, it makes little sense to contaminate one of

its main inputs. It can be argued that groundwater contamination in isolated areas does not present a problem for the surface-water resources. However, it appears that there are going to be many isolated contaminated areas, which in all likelyhood will differ with respect to the criteria used to maintain the groundwater quality in their vicinity. The question then arises: how many is too many and when does a little contamination become too much? It is obvious that waste-disposal site selection cannot be done on a case-by-case basis, but that the regional impact on both the groundwater and surface-water resources must be considered. Furthermore, by allowing attenuation of contaminants as a design parameter in waste-disposal site selection, portions of the subsurface are excluded from future use. Although provicions can be made to alleviate unacceptable environmental impacts in the future, it is a well-known fact that clean-up is, at best, only partially successful. Most, if not all, hydrogeologists agree that in order to protect the groundwater resources the best approach is to keep contaminants out in the first place. Attenuation should be considered as a last line of defense and definitely not as a primary design parameter.

In summary, the "reasonable use" concept of groundwater management is unreasonable, because it allows contamination of the shallow subsurface and does not offer sufficient protection of the groundwater resources for the future.

If groundwater resources are considered a vital source of fresh water for the present and the future, then industrial development, urban growth, use of agricultural chemicals, density of livestock, disposal of waste, etc., will have to be planned and controlled to maintain and protect the quality of that water.

In order to be able to properly plan land use, the quality and quantity of groundwater resources in any given area as well as the hydrogeological environment must be well defined. The aquifer area can then be zoned according to the sensitivity to contamination, and regulations developed which control the use, transporation, distribution, storage, and disposal of potential contaminants. This means a significant intrusion by senior government in municipal and private affairs and will undoubtedly be seen by local governments and individuals as a curtailment of the economic viability of industrial and agricultural activity in the areas affected by the regulations. However, control of the surface activities in land-use is not a new idea. It is being practiced extensively and successfully in all countries in Europe which rely heavily on groundwater as a fresh water source. The Environmental Protection Agency in the United States is proposing a similar approach to protect many of the groundwater resources in that country (EPA, 1983).

According to guidelines developed by EPA (1984), the groundwater resources are divided into three classes.

Class I. These are groundwater resources particularly vulnerable to contamination because of their hydrogeological characteristics. They are either an irreplaceable source of drinking water for a substantial population, or they provide water for a sensitive ecological system. Hazardous waste facilities will be banned as well as leachable pesticides. Existing waste facilities will be strictly regulated and any contamination will have to be cleaned up to background levels or standards for drinking water.

Class II. These are groundwater resources that are current or potential sources of drinking water or have other beneficial uses. They comprise the

vast majority of groundwater. The level of protection received by these resources will be in accordance with existing EPA regulations. In areas where the groundwater is vulnerable to contamination and is currently used for drinking water, new hazardous waste facilities will be banned and current contaminating facilities will have to clean up to drinking water quality or background levels. Where contamination can be contained by plume management and protection of human health and the environment can be demonstrated, the stringent clean-up requirements may be waived.

Class III. These are groundwater resources that, because of natural or man-made contamination levels, are not considered potential sources of drinking water and have limited beneficial use. The protection of these resources will be less stringent. However, technology standards for hazardous waste facilities would be the same as for the other classes. If contamination does occur, a waiver could be granted to clean up to a less stringent concentration limit for contaminants since the groundwater is already of limited value. However, such waivers would not be available to facilities causing contamination that precludes future use of the groundwater.

Although the EPA could legally draft legislation for all of the United States under the Clean Water Act, the Safe Drinking Water Act, and a number of other laws pertaining to water, at present it is encouraging the states to draft their own legislation, the rationale being that an overarching approach to the problem would not work because geology, hydrogeology, and possible sources of contamination differ widely among states.

A similar variation of conditions exists in Canada. Because of the diversity in land-use and in its effects on the economic base in the various provinces,

and because of the differences in the sources of water used by the various economic sectors in each province, the level of protection awarded to the groundwater resources and the enforcement of the regulations varies widely among provinces. As has been mentioned in several places in this report, groundwater and surface water form part of an interactive system. In addition, a significant portion of the surface-water resources represents continuous discharge of groundwater, especially in winter. Protection of the groundwater resources is therefore paramount not only in those areas which rely on this resource, but equally important in those areas which use primarily surface water. In order to protect the quality of the surface water resources for future use in Canada, the federal government should assume a much more active role. Although it is realized that groundwater is a provincial resource, the protection of this resource is in the national interest, and should as such be defined in a policy of the federal government. The operational aspects of such a policy could be left to the provincial governments and tailored to their own unique economic and hydrogeological environments. This approach would be similar to that used in the United States. The overriding role of the federal government would guarantee a uniform approach to the protection of the groundwater resources in Canada.

The province of Quebec appears to be moving rapidly in the direction of land-use control. Municipalities have been organized into regional districts for the purpose of land-use planning. One of the parameters considered is the sensitivity to contamination of the groundwater resources for a particular use of land. Maps identifying groundwater contamination-potential have been prepared for a number of areas, for example the Mirabel region (Simard, 1977).

Recently, pesticides were found in the groundwater in a number of areas. To avoid large-scale problems, the Quebec government plans to determine the sensitivity of agricultural lands to downward migration of pesticides. Once this information has been collected, a licensing system for their use will be initiated.

The control and regulation of pesticides , as well as their impact on the environment and human health, fall under federal jurisdiction. The responsibility for control is generally shared with the provinces. Whereas surface waters have been monitored routinely for pesticides over the last decade, groundwater surveys have only recently begun. Most of this work was done in eastern Canada. The results of these surveys indicate that pesticides are present in the groundwater in a number of places. Since the federal government is the primary agency in the control of pesticides, it should initiate, in cooperation with the provinces, a monitoring program of the groundwater resources to determine the extent and severity of the contamination, and conduct a cause-and-effect study. The results from this study can then be used in the testing program for certification and to adopt and implement appropriate controls.

A concerted effort should be made by the federal government and the provincial governments to assess the degree of groundwater contamination in the vicinity of abandoned mine sites. In many of the old mining districts long-term monitoring of the surface water environment has shown that the abandoned mine sites have had a considerable deleterious impact on water quality. Although surface input of contaminants can be readily identified, little or nothing is known about the extent and degree of groundwater

contamination, nor is the contribution by groundwater discharge to the total contaminant loading of the surface water resources known. This information will be required in any scheme for the restoration of the quality of surface-water resources, especially if it is considered that it could represent a very significant cost factor in the required remedial work.

One of the main problems encountered during the preparation of this report was a lack of access to specific information on incidence and magnitude of groundwater contamination caused by various types of waste in the provinces. Without a proper data base the assessment of the stress on groundwater resources caused by contamination is speculative at best. In order to properly manage groundwater resources and adopt and implement appropriate controls to protect the resource for continuing use in the future, readily accessible data banks should be available, not only for in-house use but also for outside examination.

VI. CONCLUSIONS AND RECOMMENDATIONS

Demands on water in surface-water systems will increase significantly in the future, especially in western Canada. Additional withdrawals and reservoir construction will alter existing groundwater flow regimes. The cumulative effects will be changes in the downstream surface-water quality, which in many cases will have inter-provincial ramifications. The available data base is in most instances inadequate to assess long-term effects and should be improved by a considerable research and planning effort on the part of the federal government.

The cost-benefit ratio of artificial recharge to supplement existing groundwater supplies as an alternative to surface-water storage schemes for water supply should be more thoroughly evaluated. Artificial recharge significantly reduces losses of water through evaporation, improves the colour and taste of surface water, and provides temperature stabilization. Furthermore, the surface area required for artificial recharge schemes is only a fraction of the area required for equivalent volume storage in surface reservoirs. In addition, artificial recharge can be used to arrest saltwater intrusion in coastal areas, simultaneously increasing the volume of groundwater available for withdrawal.

The incidence, degree, and extent of groundwater contamination across Canada are poorly defined. It is therefore suggested that the federal government, in cooperation with the provinces, initiate a national data bank on groundwater contamination. Not only would such a central registry provide a real time overview of the quantitative and qualitative stresses on Canadian

groundwaters, but it will also aid in identifying common denominators and/or specific contaminants which require changes in existing regulations.

The quality of groundwater resources in Canada is poorly defined. In comparison to surface-water resources, the systematic long-term monitoring of the quality of groundwater is still in its infancy. Little or no information is available on heavy metals in groundwater or organic compounds deleterious to health. The federal government should investigate the possibility of initiating a groundwater quality monitoring program in cooperation with the provinces. This program could run parallel to the surface-water quality sampling program that is conducted and administered by Environment Canada.

In many areas in Canada, leachate from abandoned mines and mine tailings poses a threat to the quality and the biocommunity of the surface water in their vicinity. Little or no information is available on the extent and the degree of groundwater contamination and the contribution to the contaminant load in the surface water due to discharge of contaminated groundwater. This information should be available for the design of the most cost-effective clean-up program. It is suggested that the federal government conduct a number of detailed studies at abandoned mine tailing sites in different hydrogeological and climatic settings to determine the magnitude of the potential contribution of contaminated groundwater to the surface water.

The protection of groundwater resources in Canada varies according to the significance of the resource as a source of drinking water and the availability of alternate surface-water sources. To provide for uniformity in the protection of this resource across Canada, the federal government should assume a more active role and formulate a national groundwater

protection strategy in order to assure the present and future use in the national interest. Because of the similarities in geology, hydrogeology, and land-use between Canada and the United States, the strategy developed by the Environmental Protection Agency in the United States could serve as a model for Canada. Once guidelines and specific requirements have been developed, their implementation could be delegated to the provinces.

REFERENCES

Baar, C.A., 1972. Actual geological problems in Saskatchewan potash mines. Sask. Res. Council Rept. E72-18.

Baar, C.A., 1977. Applied salt rock mechanics, Volume 1. Amsterdam: Elsevier.

Barney, G.O., 1980. The global 2000 report to the president. Washington, D.C., U.S. Gov. Printing Office.

Bates, T.E., 1972. Land application of sewage sludge. Report on Project 71-4-1 Canada-Ontario Agreement, Research Rept. no. 1, Environment Canada & Ontario Ministry of the Environment.

Bitton, G., Farrah, S.R., Ruskin, R.H., Butner, J., and Chou, Y.I., 1983. Survival of pathogenic and indicator organisms in groundwater. Groundwater, v. 21, p. 405-410.

Blachford, D.P. and Ongley, E.D., 1984. Biochemical pathways of phosphorus, heavy metals and organochlorine residues in the Bow and Oldman rivers, Alberta, 1980-1981. Env. Canada, Inland Waters Directorate, Science Series no. 138.

Bottomley, D.J., Craig, D., and Johnston, L.M., 1984. Neutralization of acid runoff by groundwater discharge to streams in Canadian Precambrian Shield watersheds. Jour. Hydrol., v. 75, p. 1-26.

Brook, G.A., 1977. Surface and groundwater hydrology of a highly karsted sub-arctic carbonate terrain in northern Canada. In Tolson, J.S. and Doyle, F.L. (eds.), Karst hydrogeology. IAH Mem. 12.

Brown, I.C. (ed.), 1967. Groundwater in Canada. Dept. Energy, Mines & Resources, Econ. Geol. Rept. no. 24.

Brown, R.F. and Signor, D.C., 1974. Artificial recharge: State of the art. Groundwater, v. 12, no. 3, p. 152-160.

Canadian Water Well, 1985. Groundwater contamination, prevention easier than cleanup. v. 11, no. 1.

Christiansen, E.A., 1967. Collapse structures near Saskatoon, Saskatchewan, Canada. Can. Jour. Earth Sci., v. 5, p. 757-767.

Christiansen, E.A., 1971. Geology of the Crater Lake collapse structure in southeastern Saskatchewan, Canada. Can. Jour. Earth Sci., v. 8, p. 1505-1513.

Davison, C.C., 1984. Hydrogeological characterization at the site of Canada's underground research laboratory. Proc. Int. Groundwater Symposium on Groundwater Resources Utilization and Contaminant Hydrogeology, May 1984, Montreal, Quebec. AECL, ISBN 0-660-11599-9, p. 310-335.

Dohler, G.C. and Ku, L.F., 1970 Presentation and assessment of tides and water level records for geophysical investigations. Can. Jour. Earth Sci., v. 7, p. 607-625.

Domenico, P.A., 1972. Concepts and models in groundwater hydrology. New York: McGraw-Hill.

EMR, 1981. Canadian mineral yearbook 1981. Energy, Mines & Resources, Rept. 31.

Environmental Protection Service, 1984. Inventory of pesticide use in Prince Edward Island. Environmental Protection Service, Atlantic Region, Env. Canada, Surveillance Rept. EP-5-AR-84-10.

EPA, 1984. EPA's ground-water protection strategy. EPA Jour. July/Aug. 1984.

van Everdingen, R.O., 1971. Surface-water composition in southern Manitoba reflecting discharge of saline subsurface waters and subsurface solution of evaporites. Geol. Assoc. Canada, Spec. Paper no. 9.

van Everdingen, R.O., 1972a. Observed changes in groundwater regime caused by the creation of Lake Diefenbaker, Saskatchewan. Inland Waters Branch, Dept. Environment, Techn. Bull. 59.

van Everdingen, R.O., 1972b. Thermal and mineral springs in the Rocky Mountains of Canada. Water Management Service, Dept. Environment, Canada.

van Everdingen, R.O., 1981. Morphology, hydrology, and hydrochemistry of karst in permafrost terrain near Great Bear Lake, Northwest Territories. Env. Canada, IWD Sci. Series, no. 114.

Farvolden, R.N., 1982. Groundwater supplies for Waterloo region: The role of geology. Geoscience Canada, v. 9, no. 1, p. 68-70.

Ford, D.C. and Quinlan, J.F., 1977. Karst in Canada. In Tolson, J.S. and Doyle, F.L. (eds.), Karst Hydrogeology. I.A.H., Mem. 12.

Francis, R.M., Gale, J.E., and Atkinson, L.C., 1984. Characterization of aquifer zones in a fractured porous media. Proc. Int. Groundwater Symposium on Groundwater Resources Utilization and Contaminant Hydrogeology, May, 1984., Montreal, Quebec. AECL, ISBN 0-660-11599-9, p. 33-43.

Freeze, R.A., 1972. Role of subsurface flow in generating surface runoff: 1. Base flow contribution to channel flow. Water Resources Research, v. 8, p. 609-623.

Freeze, R.A., 1974. Streamflow generation. Review of Geophysics and Space Physics, v. 12, p. 627-647.

Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Prentice Hall.

Freeze, R.A. and Witherspoon, P.A., 1967. Theoretical analysis of regional groundwater flow: 2. Effect of watertable configuration and subsurface permeability variation. Water Resources Research, v. 3, p. 623-634.

Fyfe, W.S., 1982. Recent sediments: The frontline of environmental protection. Geoscience Canada, v. 9, no. 1, p. 71-73.

Gabert, G., 1982. Driedmeat Lake artificial recharge water supply. Stop 3, Field trip, Nat. Hydrogeol. Conf., I.A.H., Sept. 30-Oct. 4, Edmonton, Alberta.

Gabrysh, R.K. and Bonnet, C.W., 1975. Land-surface subsidence in the Houston-Galveston region. Texas Water Dev. Board. Rept. 188.

Gale, J.E., 1982. Assessing the permeability characteristics of fractured rock. G.S.A., Spec. Paper 189, p. 163-181.

Gendzwill, D.J. and Hajnal, Z., 1971. Seismic investigation of the Crater Lake structure in southeastern Saskatchewan. Can. Jour. Earth Sci., v. 8, p. 1514-1524.

Gillham, R.W., Akindunni, F., Starr, R., and O'Hannesin, S., 1984. Studies of the nitrate distribution and nitrogen transformation in a shallow sandy aquifer near Alliston, Ontario. M.O.E., Proc. Techn. Transfer Conf. no. 5, Nov . 27-28, Toronto.

Gilliland, J.A., 1969. A rigid plate model of barometric effect. Jour. Hydrol. v. 7, p. 233-245.

Gringarten, A.C., 1982. Flow-test evaluation of fractured reservoirs. G.S.A., Spec. Paper 189.

Grisak, G.E. and Cherry, J.A., 1975. Hydrogeologic characteristics of fractured till and clay confining a shallow aquifer. Can. Geotechn. Jour., v. 12, p. 23-43.

Grisak, G.E., Cherry, J.A., Vonhof, J.A., and Blumele, J.P., 1975. Hydrogeological and hydrochemical properties of fractured till in the Intrior Plains region. In Legget, R.F. (ed.), Glacial till. Royal Soc. Can., Spec. Pub. 12, p. 304-325.

Hantke, H., 1983. Comparison between different methods of artificial recharge. In Groundwater in resource planning. Unesco-I.A.H., Proceedings, Koblenz, Fed. Rep. Germany, Aug. 28-Sept. 3, 1983.

Hawley, J.R., 1977. The use, characteristics and toxicity of mine-mill reagents in the Province of Ontario. Pollution Control Branch, Ont. Min. of Environment, Toronto.

Hendry, M.J., Gillham, R.W., and Cherry, J.A., 1983. An integrated approach to hydrogeological investigation: A case history. Jour. Hydrol., v. 63, p. 211-232.

Hendry, M.J., McCready, R.G.L., and Gould, W.D., 1984. Distribution, source, and evolution of nitrate in glacial till, southern Alberta, Canada. Jour. Hydrol., v. 70, p. 177-198.

Hess, P.J., 1984. Groundwater use in Canada. Report prepared for the Federal Inquiry on Water Policy (in press).

Holter, M.E., 1969. The Middle Devonian prairie evaporite of Saskatchewan. Sask. Dept. Mineral Resources Rept. 123.

Holzer, T.L. and Bluntzer, R.L., 1984. Land subsidence near oil and gas fields, Houston, Texas. Ground Water,v. 22, p. 450-459.

Hubbert, M.K., 1940. The theory of groundwater motion. Jour. Geol. v. 48, p. 785-944.

International Joint Commission, 1979. International Poplar River water quality study, Appendix E: Plant, mine and reservoir operations. Poplar River Water Quality Board, Windsor, Ont.

Jacob, C.E., 1940. On the flow of water in an elastic aquifer. Am. Geophys. Union Trans., v. 21, p. 574-586.

de Jong, E., 1980. Reclamation problems and procedures for the oil industry on the Canadian Prairies. Reclamation Rev., v. 3, p. 75-85.

Kashef, A.I., 1971. On the management of groundwater in coastal aquifers. Ground Water, v. 9, no. 2, p. 12-20.

Kashef, A.I., 1975. Management of retardation of salt water intrusion in coastal aquifers. U.S. Dept. Interior, Office for Research and Technology.

Kashef, A.I., 1976. Control of saltwater intrusion by recharge wells. Proc. Am. Soc. Civ. Eng., v. 102, IR 4.

Kohout, F.A., 1960. Flow pattern of fresh and salt water in the Biscayne aquifer of the Miami area, Florida. I.A.H., Pub. 52, p. 440-451.

Kohut, A.P., Hodge, W.S., Johanson, D.A., and Kalyn, D., 1984. Natural seasonal response of groundwater levels in fractured bedrock aquifers of the southern coastal region of British Columbia. Proc. Int. Groundwater Symposium on Groundwater Resource Utilization and Contaminant Hydrogeology, May 1984, Montreal, Quebec. AECL, ISBN 0-660-11599-9, p. 97-107.

Kruseman, G.P. and De Ridder, N.A., 1970. Analysis and evaluation of pumptest data. Int. Inst. Land Reclamation and Improvement, Wageningen, The Netherlands, Bull. 11.

Last, F.T., Likens, G.E., Ulrich, B., and Walløe,L., 1980. Acid precipitation - progress and problems. In Drabløs, D. and Tollan, A. (eds.), Ecological impact of acid precipitation. Proc. Int. Conf. Sondefjord, Norway, March 11-14, 1980.

Lindsay, W.L., 1979. Chemical equilibria in soils. New York: Wiley-Interscience.

Maathuis, H. and Van der Kamp, G., 1983. Influence of salt tailings pile on groundwater flow: A case history in Saskatchewan, Canada. In McKercher, R.M. (ed.), Potash technology. Proc. 1st Int. Potash Techn. Conf. Pergamon Press,

Marshall, I.B., 1982. Mining, land use, and the environment, I. A Canadian overview. Lands Directorate, Env. Canada, Ottawa, Ont.

Marshall, I.B., 1983. Mining, land use, and the environment, II. A review of mine reclamation activities in Canada. Lands Directorate, Env. Canada, Ottawa, Ont.

McKechnie, R., Simpson-Lewis, W., and Neimanis, V., 1983. Sanitary landfills and their impact on land. In Simpson-Lewis, W., McKechnie, R., and Neimanis, V. (eds.), Stress on land. Policy Res.and Dev. Branch, Land Directorate, Env. Canada, Ottawa, Ont.

McNeely, R.N., Neimanis, V.P., and Dwyer, L., 1979. Water quality source book: A guide to water quality parameters. Inland Waters Directorate, Water Quality Branch, Env. Canada, Ottawa, Ont.

MOE, 1984a. Blueprint for waste management in Ontario, Appendix 3: Perpetual Care Program Report. Ministry of the Environment, Toronto, Ont.

MOE, 1984b. The incorporation of the reasonable use concept into the groundwater management activities of the Ministry of the Environment. Water Management Steering Committee, Water Resources Branch, Ont. Ministry of Environment, July 1984. Toronto, Ont.

Moran, S.R. and Cherry, J.A., 1977. Subsurface-water chemistry in mined-land reclamation: Key to development of a productive post-mining landscape. Can. Land Reclamation Assoc. 2nd Ann. Meeting, Aug. 17-20, 1977, Edmonton.

Morris, W.V., 1969. Water. Inland Waters Branch, Dept. Energy, Mines, and Resources, Ottawa, Ont.

Morrow, D.W., 1982a. Diagenesis 1. Dolomite - Part 1: The chemistry of dolomitization and dolomite precipitation. Geoscience Canada, v. 9, no. 1, p. 5-13.

Morrow, D.W., 1982b. Diagenesis 2. Dolomite - Part 2: Dolomitization models and ancient dolostones. Geoscience Canada, v. 9, no. 2, p. 95-107.

Newbury, R.W., Cherry, J.A., and Cox, R.A., 1969. Groundwater-streamflow systems in Wilson Creek Experimental Watershed, Manitoba. Can. Jour. Earth Sci., v. 6, p. 613-623.

Nightingale, H.I., 1975. Lead, zinc, and copper in soils of urban storm runoff retention basins. Jour. AWWA, Aug. 1975, p. 443-446.

Ozoray, G., 1977a. Groundwater potential of the karst regions of Alberta. In Dillamarter, R.R. and Csallany, S.C. (eds.), Hydrologic problems in karst regions. I.A.H., p. 235-240.

Ozoray, G., 1977b. The Athabasca carbonate and evaporite buried karst. In Tolson, J.S. and Doyle, F.L. (eds.),Karst hydrogeology, I.A.H. Mem 12.

Pearson, R., 1984. An overview of hydrogeological field research in the Canadian nuclear waste management program. Proc. Int. Groundwater Symposium on Groundwater Resources Utilization and Contaminant Hydrogeology, May, 1984, Montreal, Quebec. AECL, ISBN 0-660-11599-9, p. 484-497.

Poland, J.F. and Davis, G.H., 1969. Land subsidence due to withdrawal of fluids. In Varves, D.V. and Kiersch, G. (eds.), Reviews in Engineering Geology. G.S.A., v. 2, p. 187-269.

Poland, J.F., Lofgren, B.E., Ireland, R.L., and Pugh, R.G., 1975. Land subsidence in the San Joaquin Valley, California as of 1972. U.S.G.S. Prof. Paper 437-H.

Poulin, M.,Simard, G., and Sylvestre, M., 1984. Pollution des eaux souterraines par les composés organiques à Mercier, Quebec. Proc. Int. Groundwater Symposium on Groundwater Resources Utilization and Contaminant Hydrogeology, May, 1984, Montreal, Quebec. AECL, ISBN 0-66011599-9.

Rebhun, M. and Schwarz, J., 1968. Clogging and contamination processes in recharge wells. Water Resources Res., v. 4, p. 1207-1217.

Rowley, W.J., 1975. A study of water pollution in the vicinity of Flin Flon, Manitoba. Env. Prot. Service, Env. Canada, Surveillance Rept. EPS-5-NW-75-7.

Roy, A.C. and Keller, W., 1976. Status Report: Water pollution in the Serpent River Basin. Ont. Ministry of Environment, N.E. Region, Sudbury, Ont.

Rutherford, G.K. and Bray, C.R., 1979. Extent and distribution of soil heavy metal contamination near a nickel smelter at Coniston, Ontario. Jour. Env. Quality, v. 8, no. 2, p. 219-222.

Schoonbeek, J.B., 1977. Land subsidence as a result of gas extraction in Groningen, The Netherlands. In 2nd Int. Land Subsidence Symposium Proc. I.A.H. Sci. Pub. 121, p. 267-284.

Shank, G., 1983. Pesticide use in New Brunswick. Env. Services Branch, Dept. Environment, Prov. of New Brunswick.

Simard, G., 1977. Vulnerabilité des nappes aquifères a la pollution, région de Mirabel. Service des Eaux Souterraines, Min. Environnement, Quebec.

Simpson Lewis, W., McKechnie, R., and Neimanis, V., 1983. Stress on land. Policy Res. & Dev. Branch, Land Directorate, Env. Canada, Ottawa, Ont.

Skinner, A., 1983. Groundwater development as an integral part of river basin resource systems. In Groundwater in resource planning. Unesco-I.A.H. Proc., Koblenz, Fed. Rep. Germany, Aug. 28-Sept. 3, 1983.

Streltsova, T.D. and Kashef, A.I., 1974. Critical state of saltwater upconing beneath artesian discharge wells. Water Resources Bull., v. 10, p. 995-1008.

Stumm, W. and Morgan, J.J., 1970. Aquatic chemistry. New York, Wiley-Interscience.

Terzaghi, K., 1925. Erdbaumechanik auf bodenphysikalisher Grundlage. Vienna: Deuticke.

Tinsley, I.J., 1979. Chemical concepts in pollutant behaviour. New York: Wiley-Interscience.

Todd, D.K., 1974. Saltwater intrusion and its control. Jour. AWWA, Water technology/resources, March 1974, p. 180-187.

Tóth, J., 1963. A theoretical analysis of groundwater flow in small drainage basins. Jour. Geophysical Res., v. 68, p. 4795-4812.

Vandenberg, A., 1975. Simultaneous pumping of fresh and saltwater from a coastal aquifer. Jour. Hydrol., v. 24, p. 37-43.

Van der Kamp, G., 1981. Saltwater intrusion in a layered coastal aquifer at York Point, Prince Edward Island. Env. Canada, NHRI Paper no. 14.

Van der Pluym, H.S.A., Paterson, B., and Holm, H.M., 1981. Degradation by salinization. Agricultural Land, Our Disappearing Heritage, Proc. 18th Ann. Alta Soil Sci. Workshop, Feb. 24,25, Edmonton, Alta.

Vonhof, J.A., 1977. Hydrogeological investigation of a gasoline spill in Flin Flon, Manitoba. Fisheries and Environment, Env. Prot. Service, Surveillance Rept. EPS-5-EC-77-1.

Vonhof, J.A., 1981. Investigation of an underground gasoline spill, April 1978, St. Eustache, Quebec. Report prepared for the town of St. Eustache.

Vonhof, J.A., 1983. Hydrogeological and hydrochemical investigation of the waste disposal basin at IMCC-K2 potash plant, Esterhazy, Saskatchewan. NHRI Paper 13, Env. Canada, Ottawa, Ont.

Wallace, R.R., Hardin, M.J., and Weir, R.H., 1975. Toxic properties and chemical characteristics of mining effluents in the Northwest Territories. Env. Prot. Service, Env. Canada Surveillance Rept. EPS-5-NW-75-4.

Walton, W.C., 1970. Groundwater resource evaluation. New York: McGraw-Hill.

Wardlaw, N.C., 1979. Pore systems in carbonate rocks and their influence on hydrocarbon recovery efficiency. In Geology of carbonate porosity. Am. Assoc. Petroleum Geologists, Cont. Ed. Course Note Series II, p. E1-E24.

Warner, D.L., 1966. Deep-well waste injection-reaction with aquifer water. Am. Soc. Civil Eng., Proc., v. 2, (SA4), p. 45-69.

Weyer, K.U., 1983. Salt dissolution, karst geology, glacial events, and groundwater flow in the Pine Point region, N.W.T. NHRI, Env. Canada (in preparation).

Weyer, K.U., 1984. Investigation of acid neutralization processes within soil-rock-water systems in Canada. NHRI, Env. Canada, May 1984 (unpublished internal report).

Weyer, K.U. and Vonhof, J.A., 1980. Water Quality? A discussion of "The effects of surface mining of coal on the water quality near Grande Cache, Alberta" by D.A. Hackbarth. Can. Jour. Earth Sci., v. 17, p. 952-955.

Wiltshire, D.A. and Evans, M.L., 1984. Acid precipitation - An annotated bibliography. U.S.G.S. Circ. 928.

Zimmermann, W., 1967. Wasser under Mineralöle. Munich/Vienna, Oldenburg Verlag.

Yerkes, R.F. and Castle, R.O., 1969. Surface deformation associated with oil and gas field operations in the United States. In 1st Int. Land Subsidence Symp. Proc., I.A.H. Sci. Pub. 88, v. 1, p. 55-66.

Zenon Environmental Enterprises Ltd., 1983. Environmental review of onshore oil and gas drilling and production activities. Env. Prot. Service, Env. Canada, Rept. no. EPS3-EP-83-2.

GLOSSARY

ANION. An ion that moves, or would move, toward an anode, hence nearly always synonymous with a negative ion.

AEOLIAN. A term applied to deposits which are formed due to the transporting action of the wind.

ATTENUATE. To reduce in value, quantity, and strength.

CATCHMENT BASIN. Drainage basin.

CATION. An ion that moves, or would move, toward a cathode, hence nearly always synonymous with a positive ion.

CATION EXCHANGE. The property of certain minerals which can sorb certain cations and retain them in an exchangeable state, i.e. these ions are exchangeable for other cations by treatment with such ions in a water solution.

CHELATION. The inactivication of metallic ions in a solution by an organic reagent with whose molecules the metallic ions are strongly bound in a relatively inactive ring structure.

CLASTIC SEDIMENTARY ENVIRONMENT. An environment where detritus is transported mechanically into its place of deposition. The commonest clastics are shale and sandstone.

COLLAPSE STRUCTURES. Structures resulting from the collapse of overlying beds into caverns formed by solutioning.

CONSOLIDATION. A process whereby loose and soft earth materials become firm and coherent.

DECALCIFICATION. The removal of calcium carbonates from the rock mass.

DIAGENETIC CHANGE. The chemical and physical changes that sediments undergo during and after their accumulation.

DIFFUSION. The process whereby ionic or molecular constituents move under the influence of their kinetic activity in the direction of their concentration gradient.

DISPERSION. The spreading of solutes in the subsurface away from their point of entry due to the branching of pore channels,which causes the solute to be diluted.

ESKER. A serpentine ridge of gravel and sand deposited by water under glaciers.

FACIES. The "aspect" belonging to a geological unit of sedimentation, including mineral composition, type of bedding, fossil content, etc. Sedimentary facies are areally segregated parts of differing nature belonging to any genetically related body of sedimetary deposits.

FLUVIAL SEDIMENTS. Sediments deposited by rivers.

GLACIO-FLUVIAL DEPOSITS. Sediments deposited by flowing water in close proximity to glaciers and ice sheets.

HOLOCENE SEDIMENT. Recent sediments, i.e. sediments deposited after those deposited during the Pleistocene epoch.

IDIOMORPHIC (Euhedral). Minerals that are bounded by their own crystal faces.

IGNEOUS ROCK. Rock formed by solidification of hot mobile material termed magma.

INTRUSIVE HISTORY. The sequence of invasions of igneous rock invading older rock.

ION. An electrically charged atom, radical, or molecule, produced by the dissolution of an electrolyte.

ISOTROPIC. A medium is isotropic with respect to permeability if it is equally permeable to flow in all directions.

KAME. A conical hill or short irregular ridge of gravel or sand deposited against the edge of an ice sheet.

LITHOFACIES. The physical character of rock which indicates its mode of origin.

MACROSCOPIC. Visible to the naked eye.

METAMORPHIC ROCK. Rock which has formed in the solid state in response to pronounced changes of temperature, pressure, and chemical environment.

OUTWASH. Stratified drift that is stream built (deposited by meltwater streams) beyond active glacier ice.

PENECONTEMPORANEOUS. A term used to describe a process that took place at almost the same time as the deposition of the material of the surrounding rock.

PERMEABILITY. Capacity for transmitting a fluid.

PIEZOMETER. The basic device for measurement of hydraulic head. It is a tube or pipe in which the elevation of a water level can be determined.

PLEISTOCENE. The earlier of the two epochs comprised in the Quaternary period, also called Glacial epoch and formerly called Ice Age.

PLUTONIC. A general term applied to a class of igneous rocks which have crystallized at great depth and have as a rule assumed a granitoid texture.

SORTED. A term used to indicate the degree of similarity of the component parts in the mass of material.

SUBSIDENCE. Local or regional sinking of the ground.

TECTONIC. Pertaining to, or designating the rock structure and external forms resulting from the deformation of the eath's crust.

TILL. A non-sorted, non-stratified sediment carried or deposited by a glacier.

UNCONSOLIDATED SEDIMENT. A loose and friable sediment.

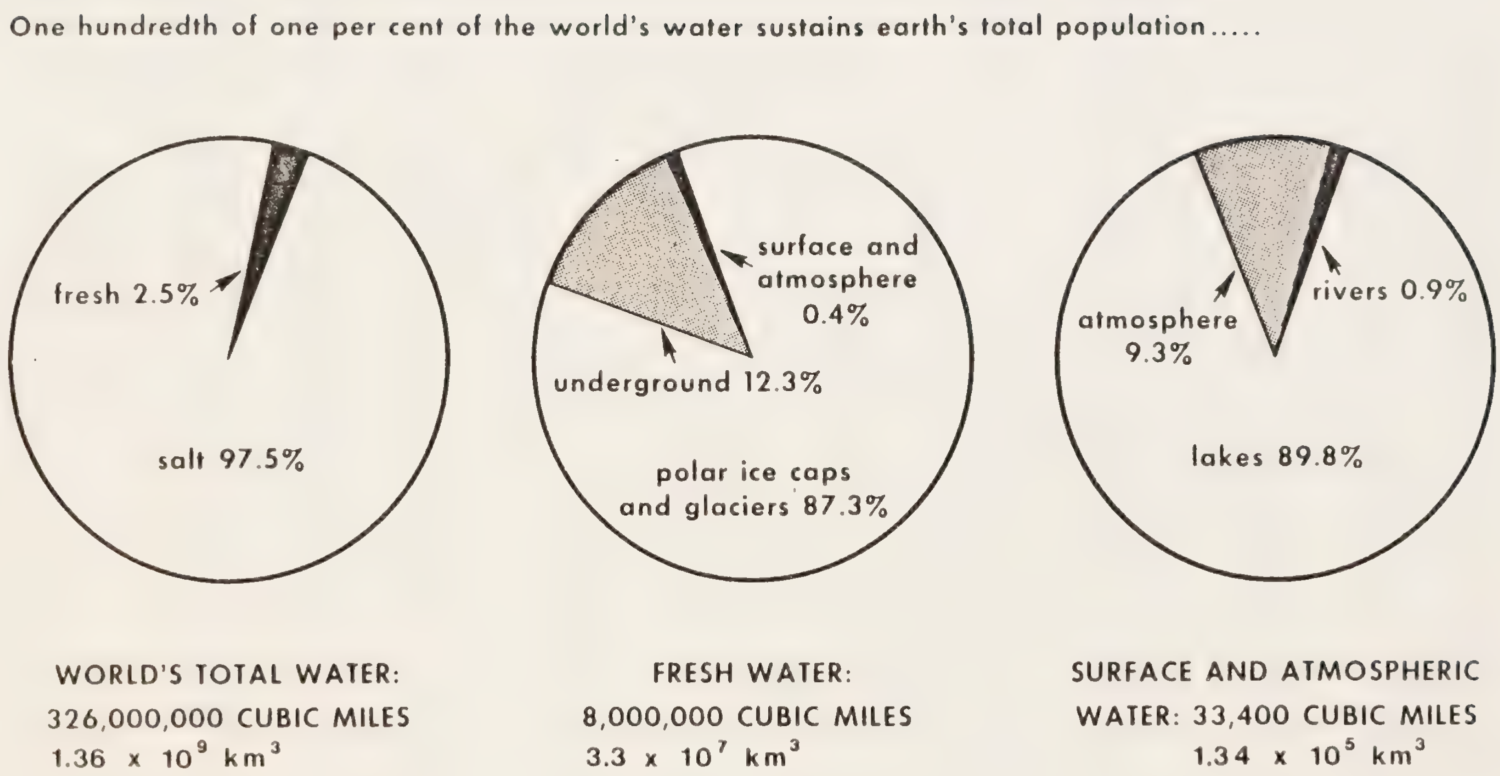


Figure 1. Distribution of water on the earth. (after Morris, 1969)

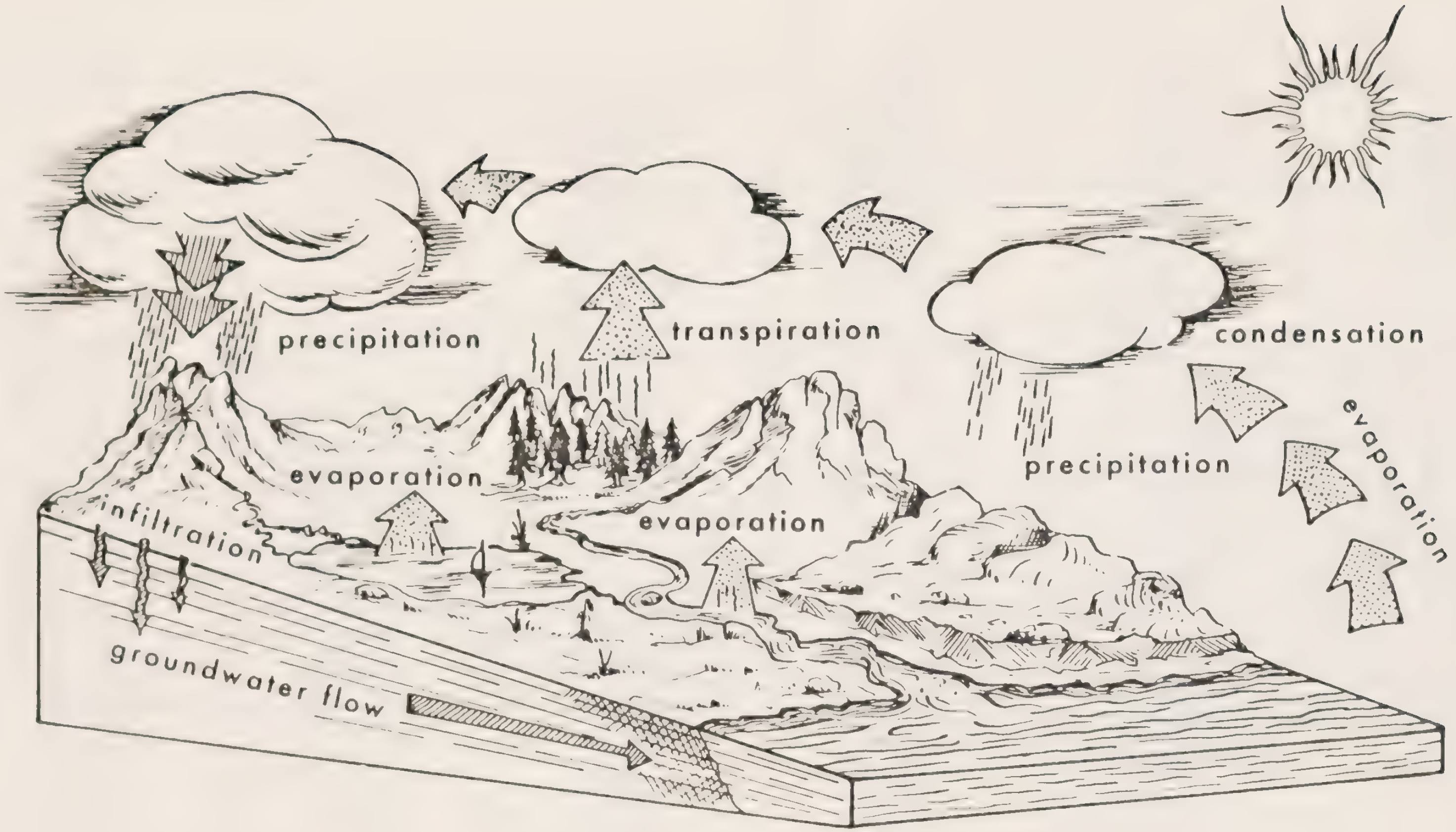


Figure 2. The hydrologic cycle (after Morris, 1969).

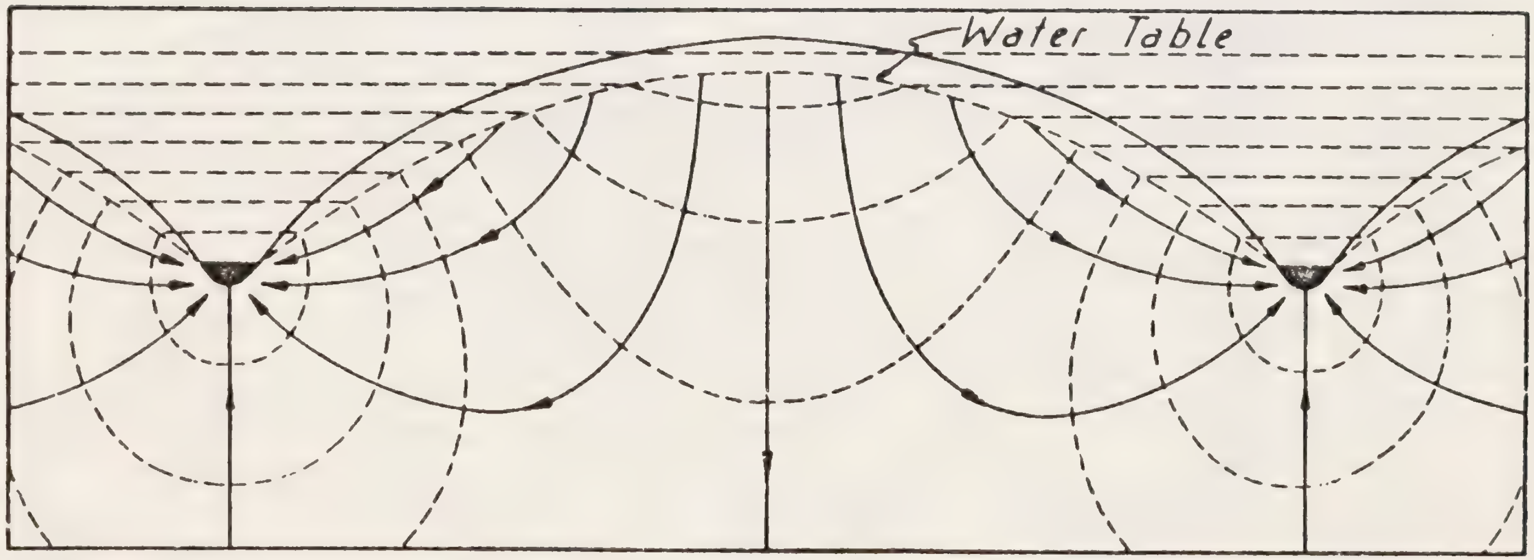


Figure 3. Approximate groundwater flow pattern in uniformly permeable material (after Hubbert, 1940)

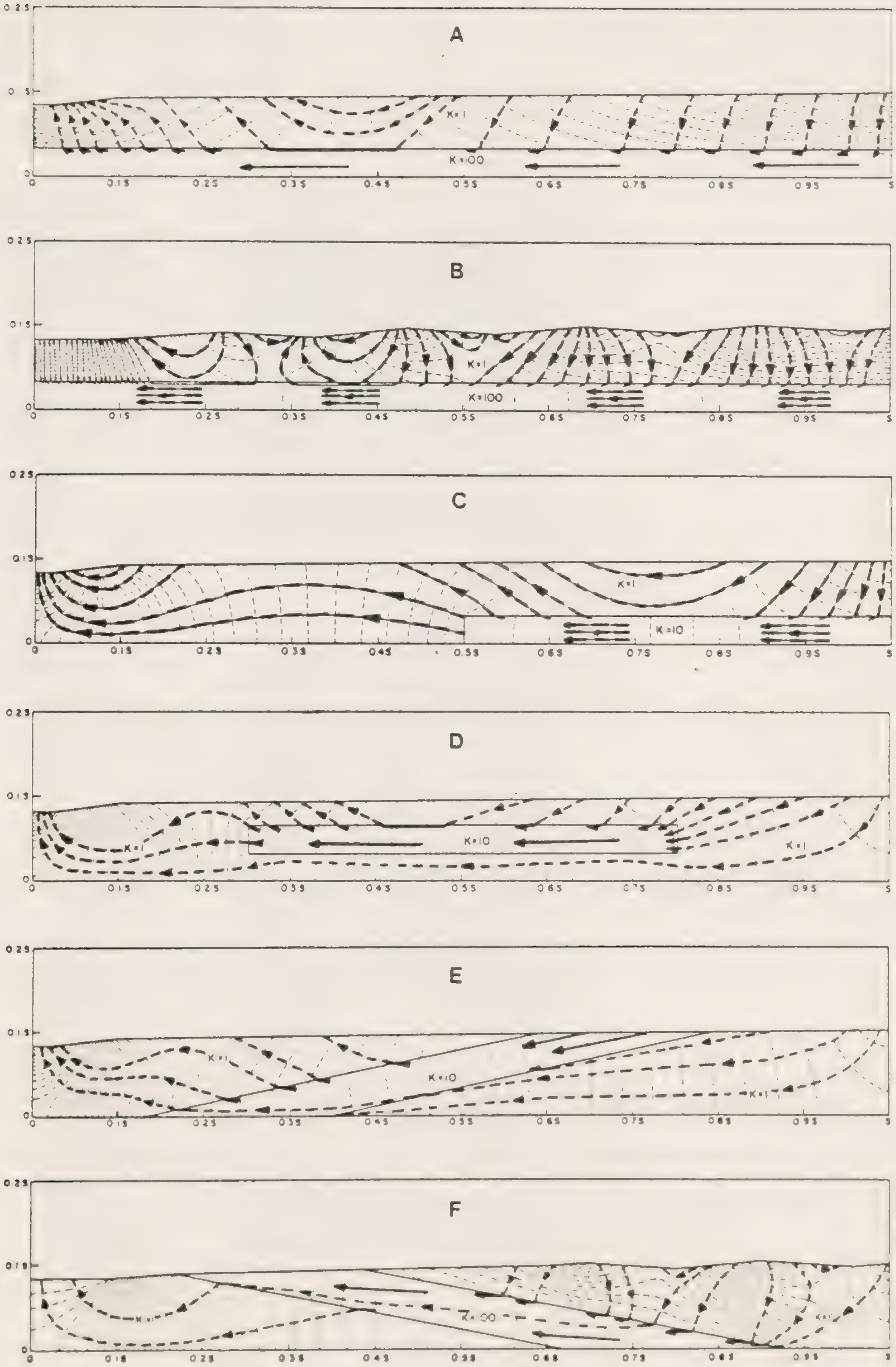


Figure 4 . Effect of topography and geology on regional groundwater flow patterns (after Freeze and Witherspoon, 1967).

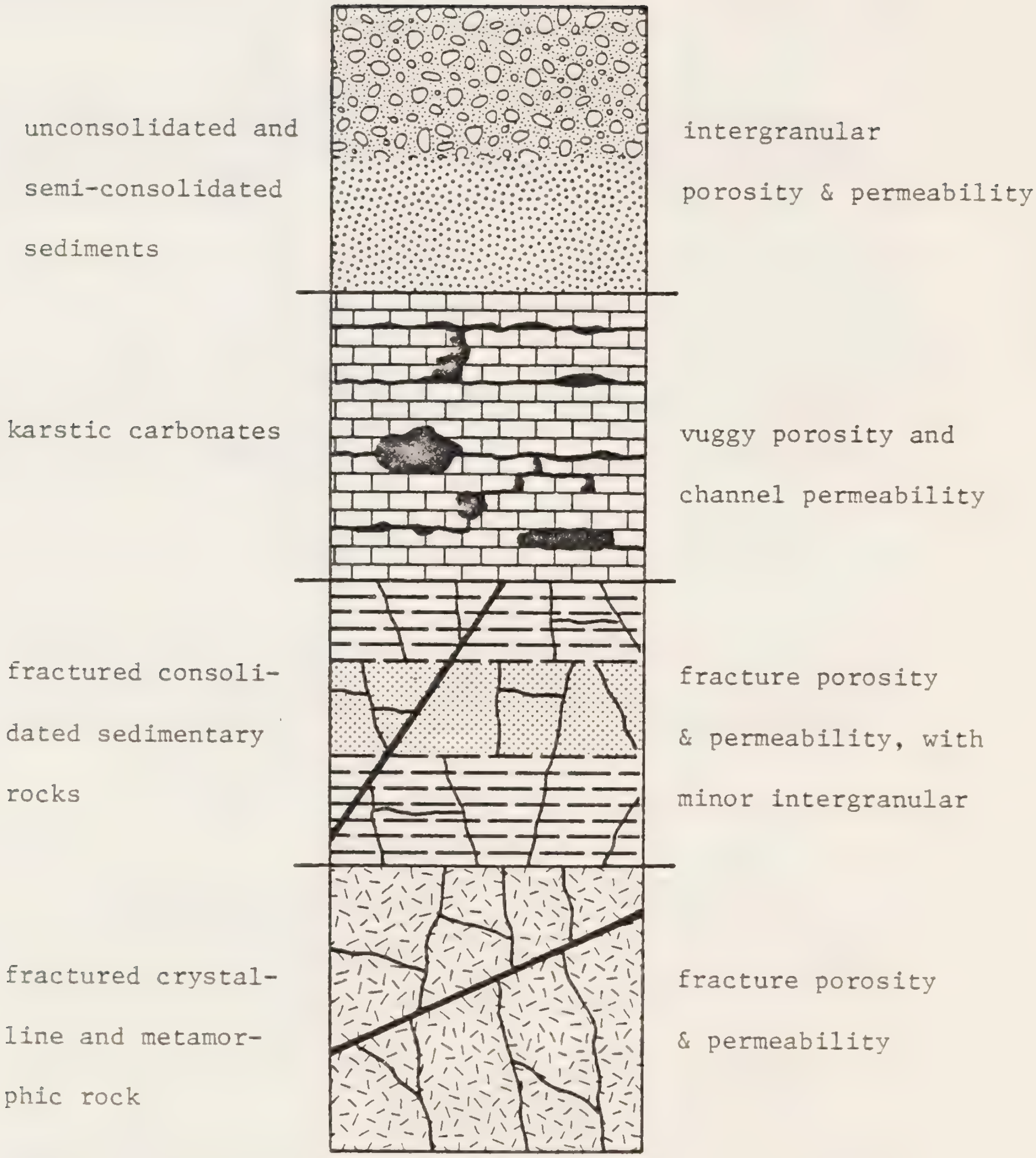


Figure 5. Texture, porosity, and permeability in major rocktypes and deposits.

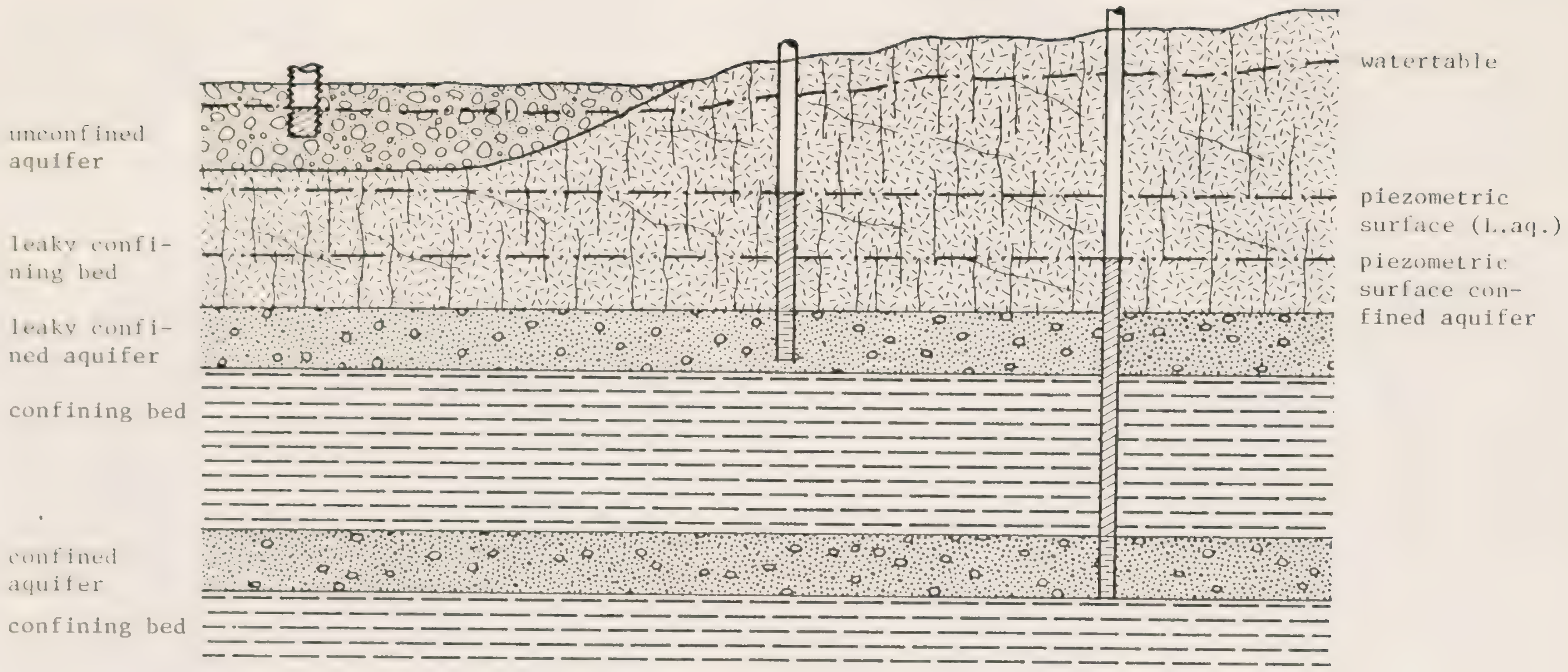


Figure 6. Unconfined, confined, and leaky aquifer.

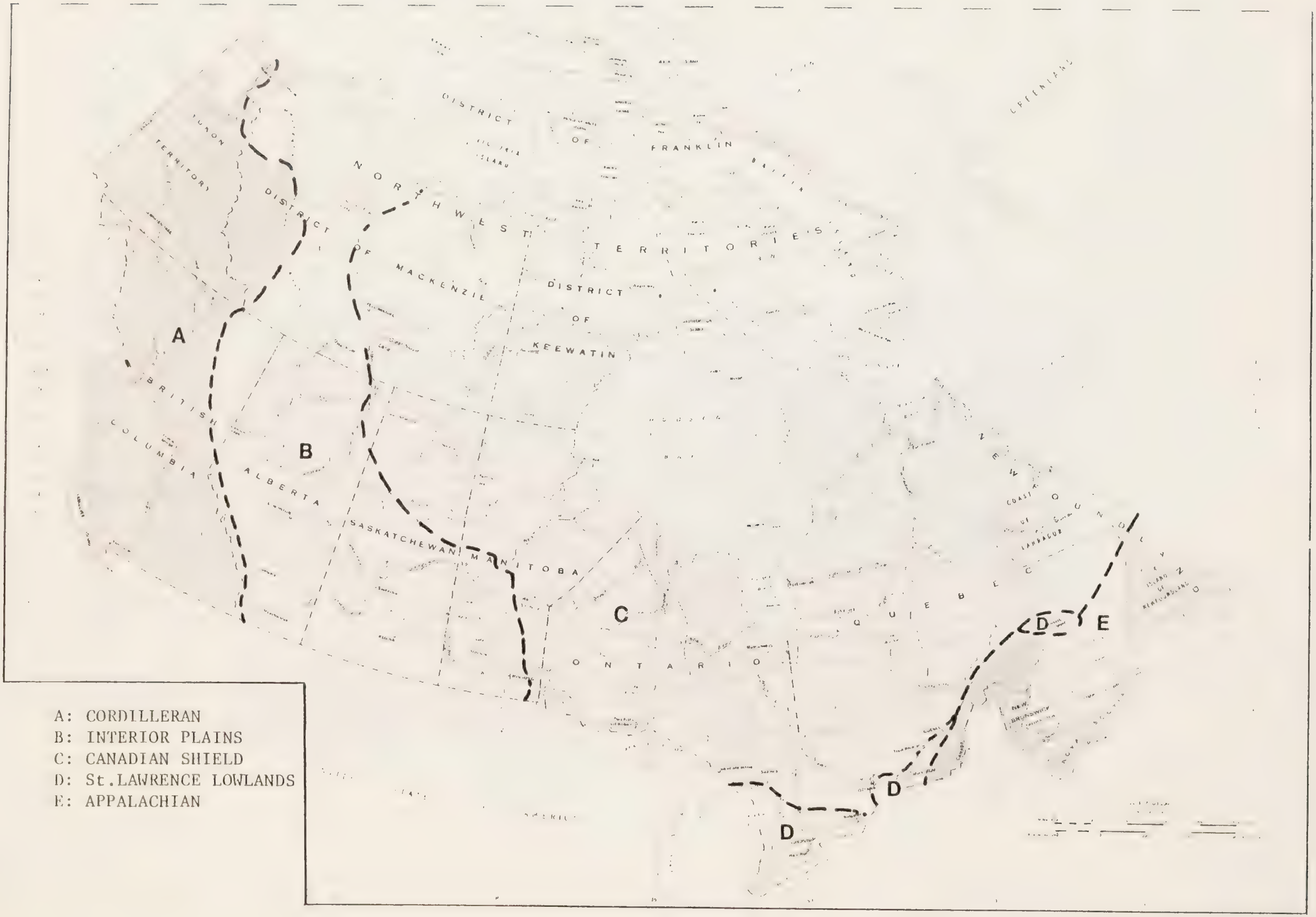


Figure 7. Distribution of main hydrogeological regions of Canada (after Brown, 1967).

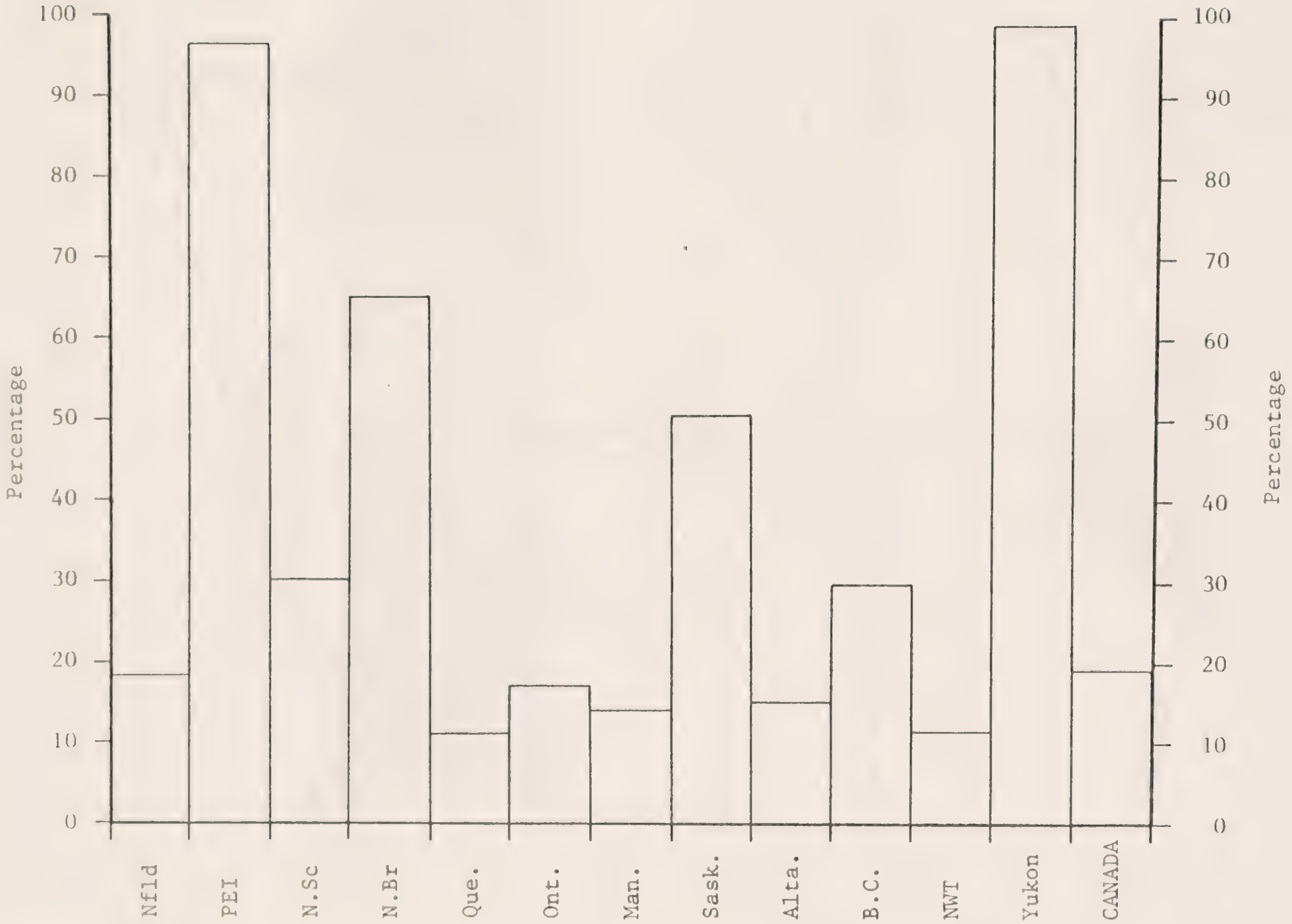


Figure 8. Groundwater component of total water use by population in provinces and Canada (after Hess, 1984).

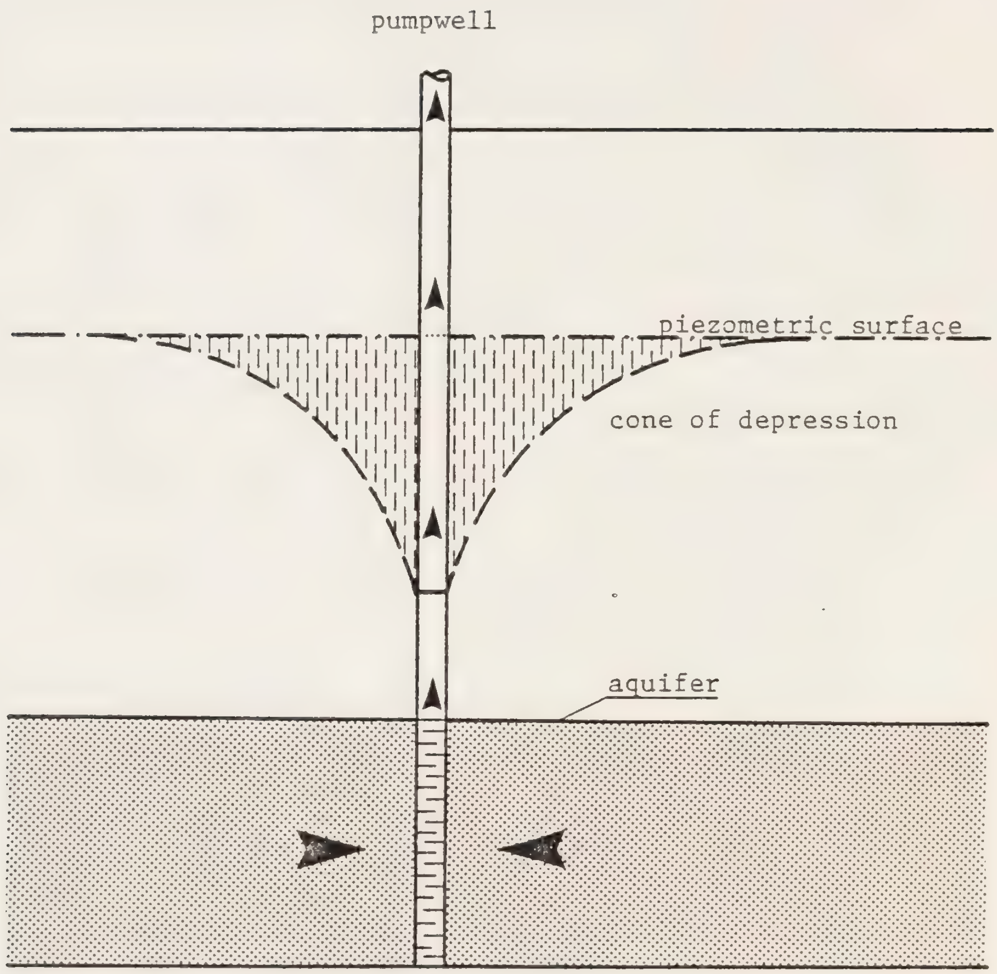


Figure 9. Cone of depression created by pumping.

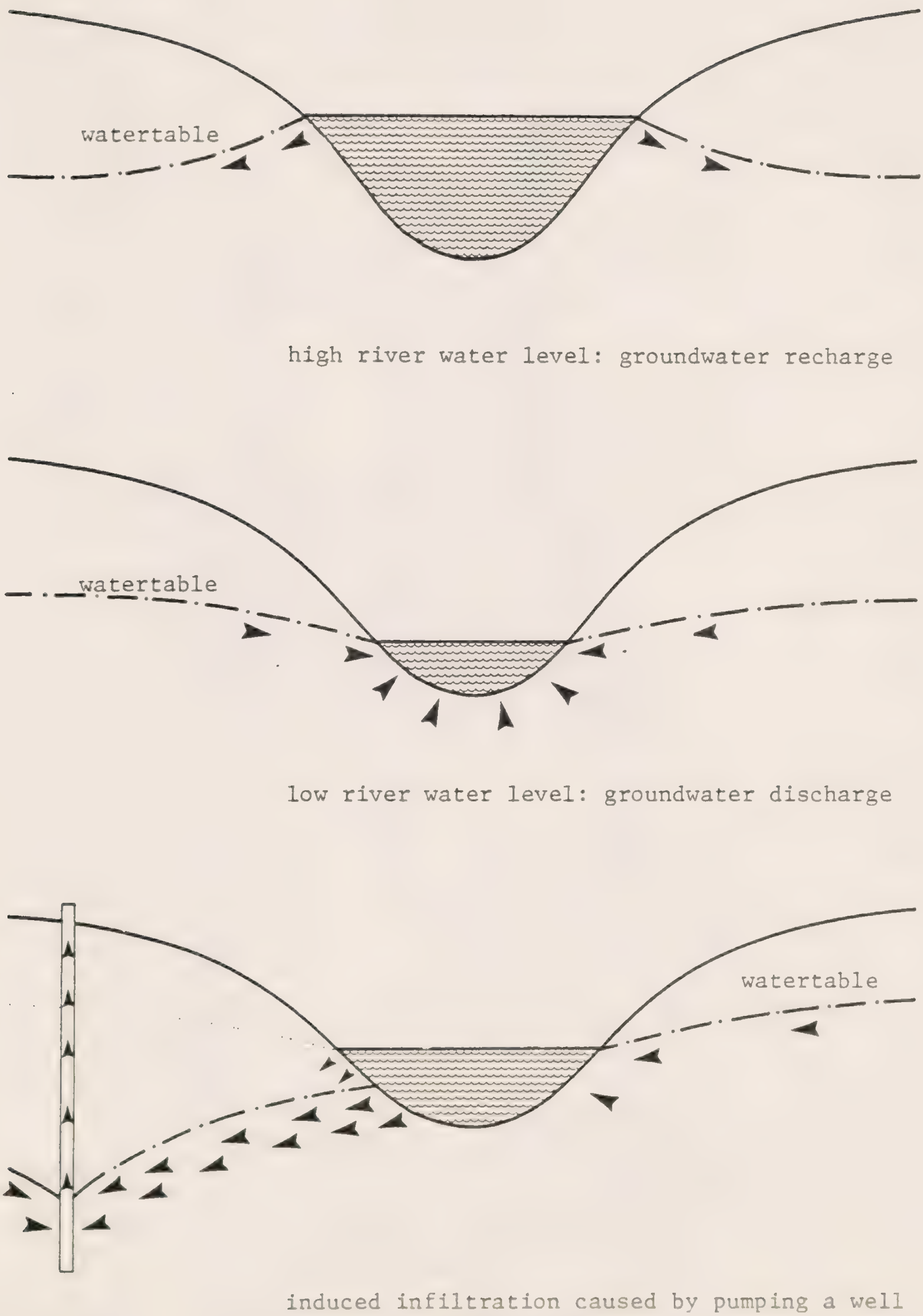


Figure 10. Relationship between groundwater flow and streamflow.

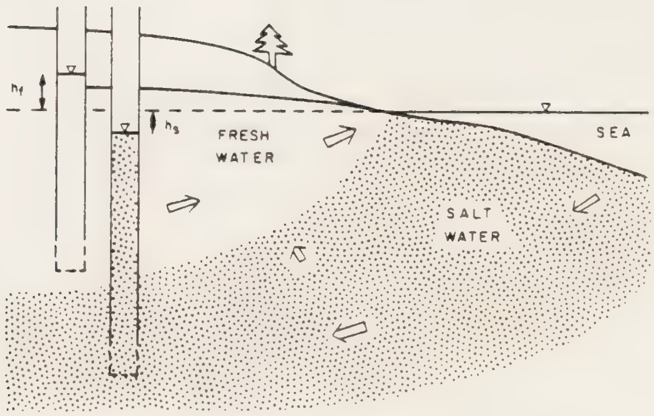


Figure 11. Fresh-salt water contact, head distribution, and flow of fresh and salt water (after Van der Kamp, 1981).

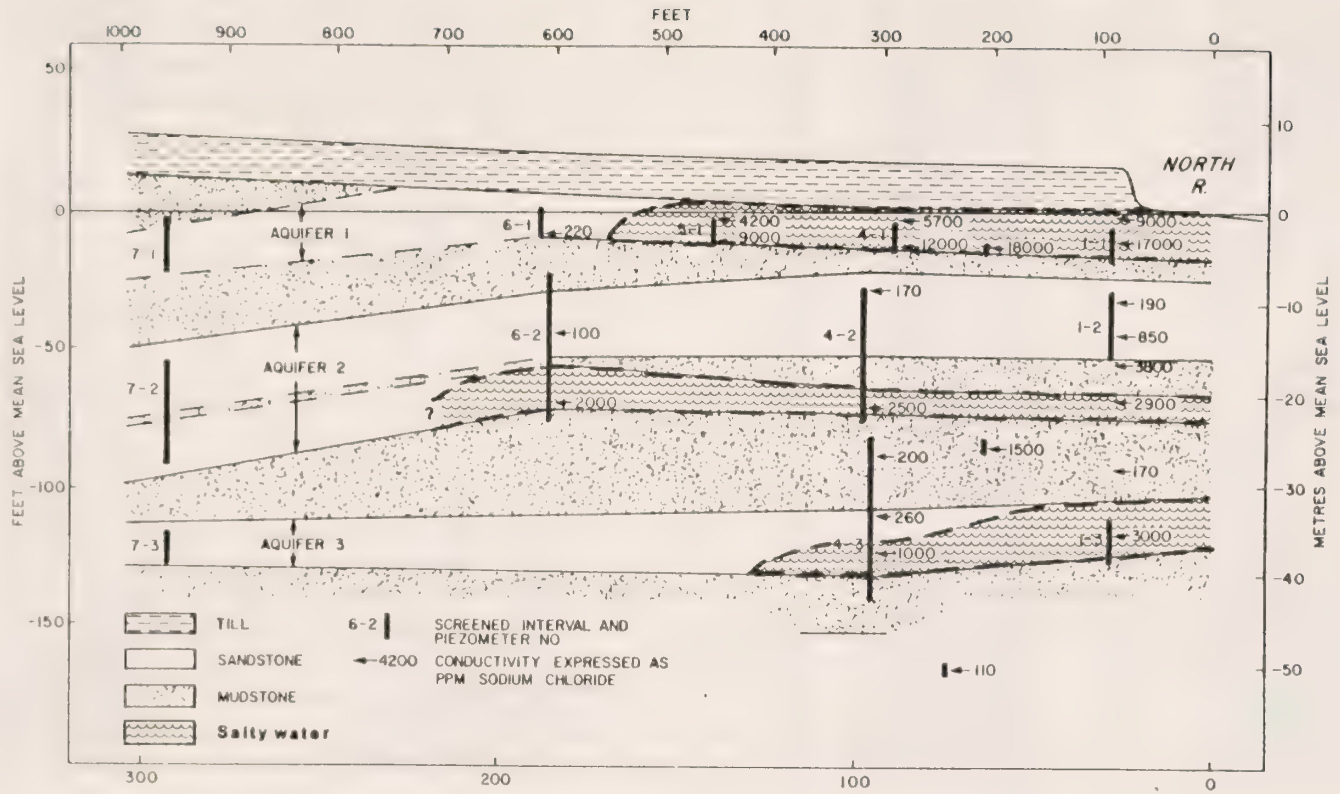
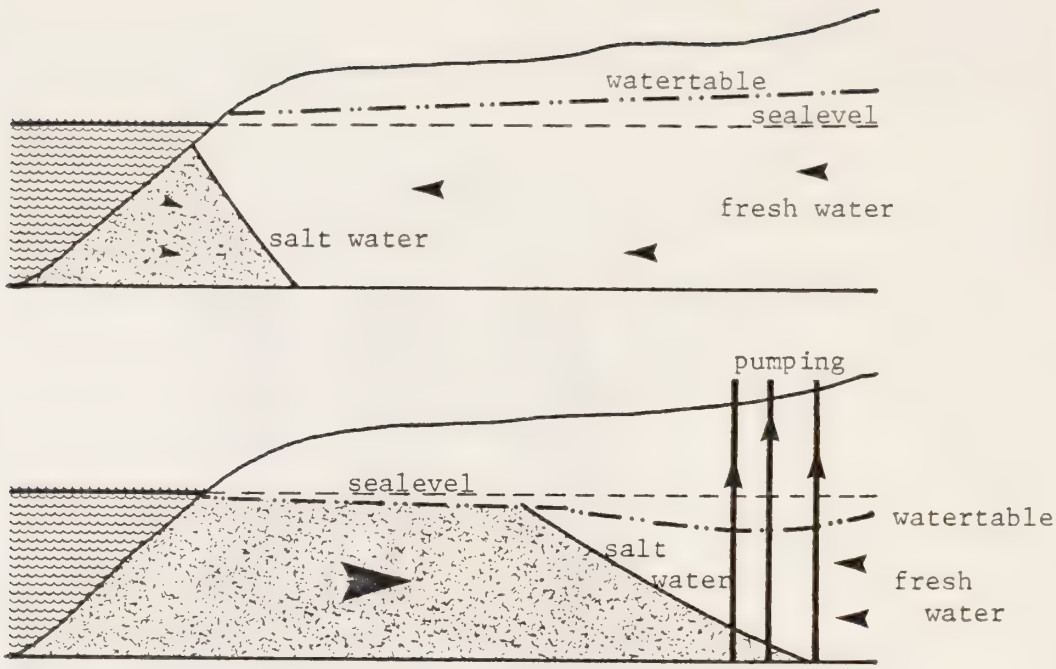
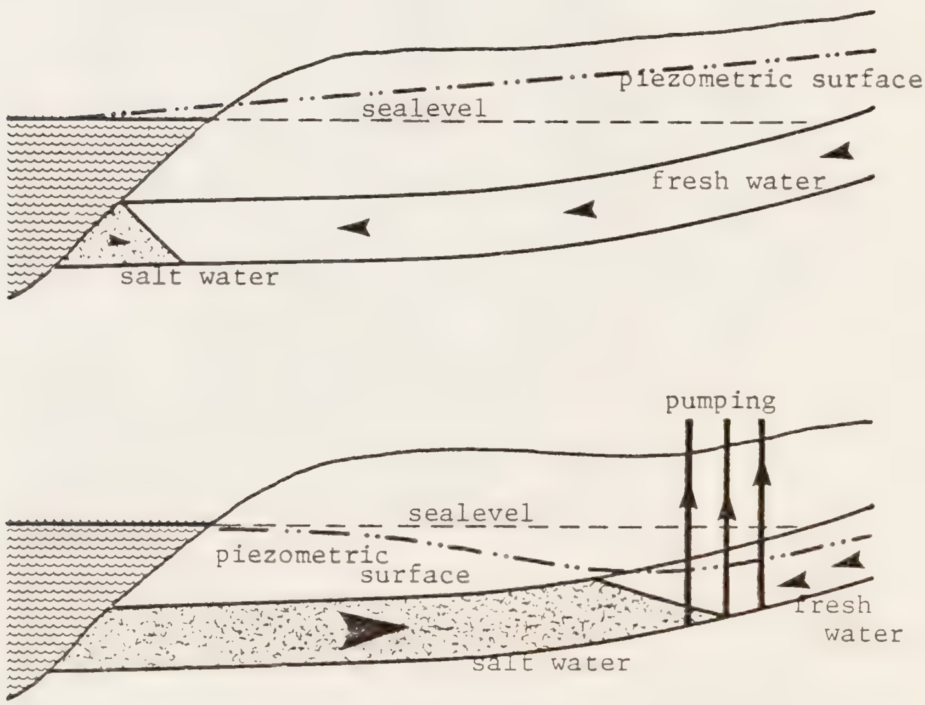


Figure 12. Hydrostratigraphy and salinities encountered during drilling at York Point, Prince Edward Island in 1970 (after Van der Kamp, 1981)

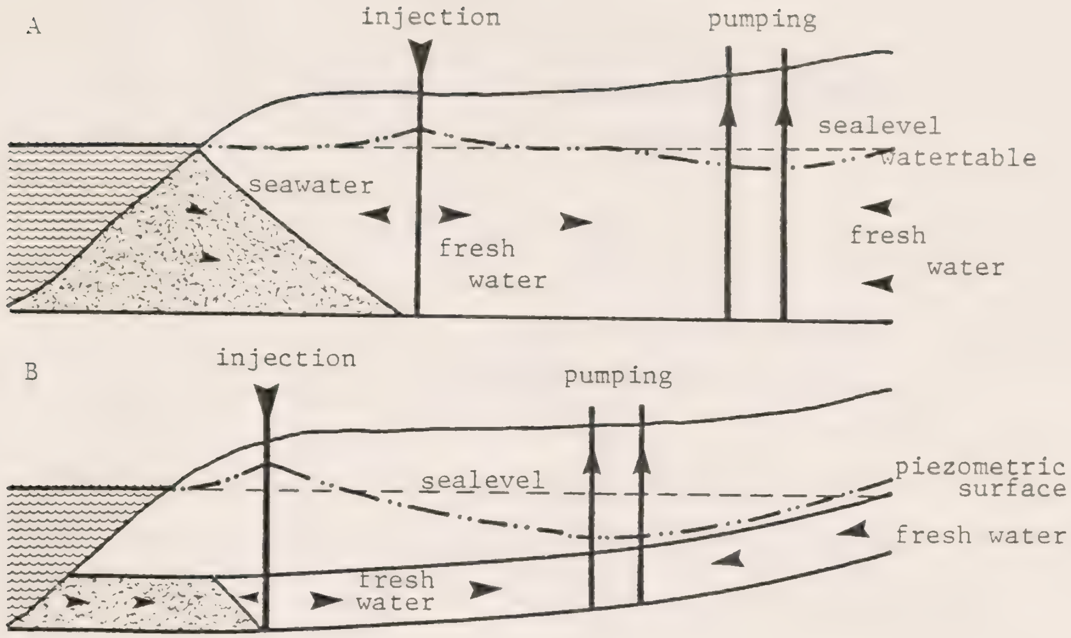


Hydrologic conditions in an unconfined aquifer

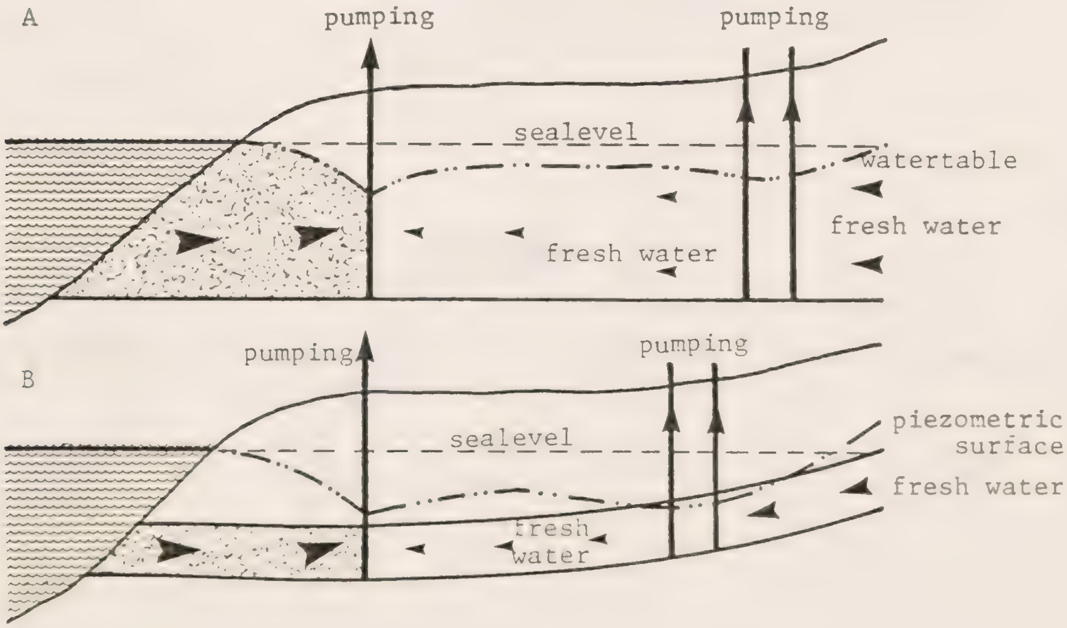


Hydrologic conditions in a confined aquifer

Figure 13. Change in hydrologic conditions due to groundwater extraction in coastal aquifers (after Todd,1974).



Hydrologic conditions with a fresh water ridge acting as a salt water barrier. A: unconfined B: confined



HYdrologic conditions with an extraction-type sea water barrier
A: unconfined B: confined

Figure 14. Conceptual diagrams of methods employed to control seawater intrusion (after Todd, 1974).

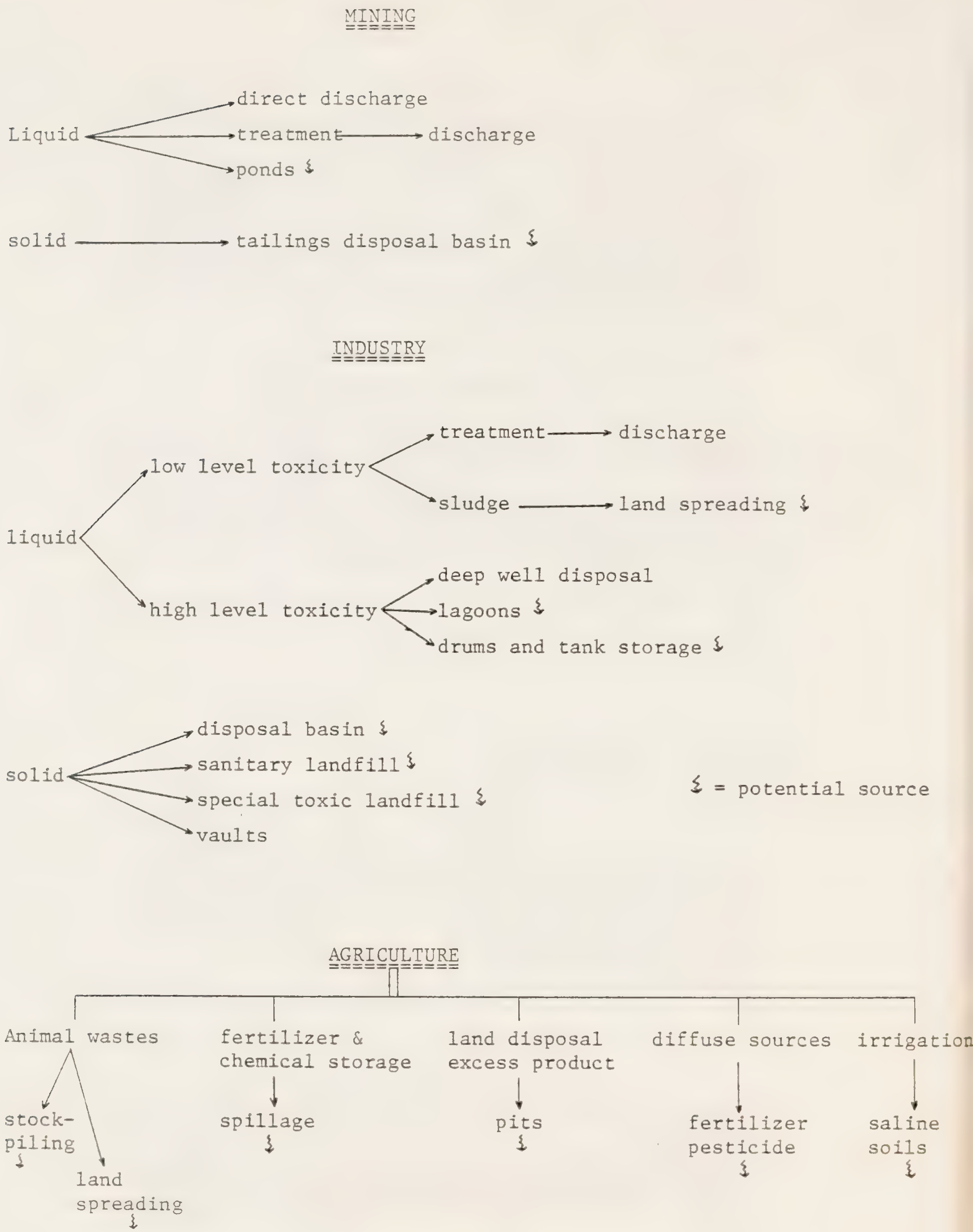


Figure 15. Disposal practices and groundwater contamination

OIL INDUSTRY

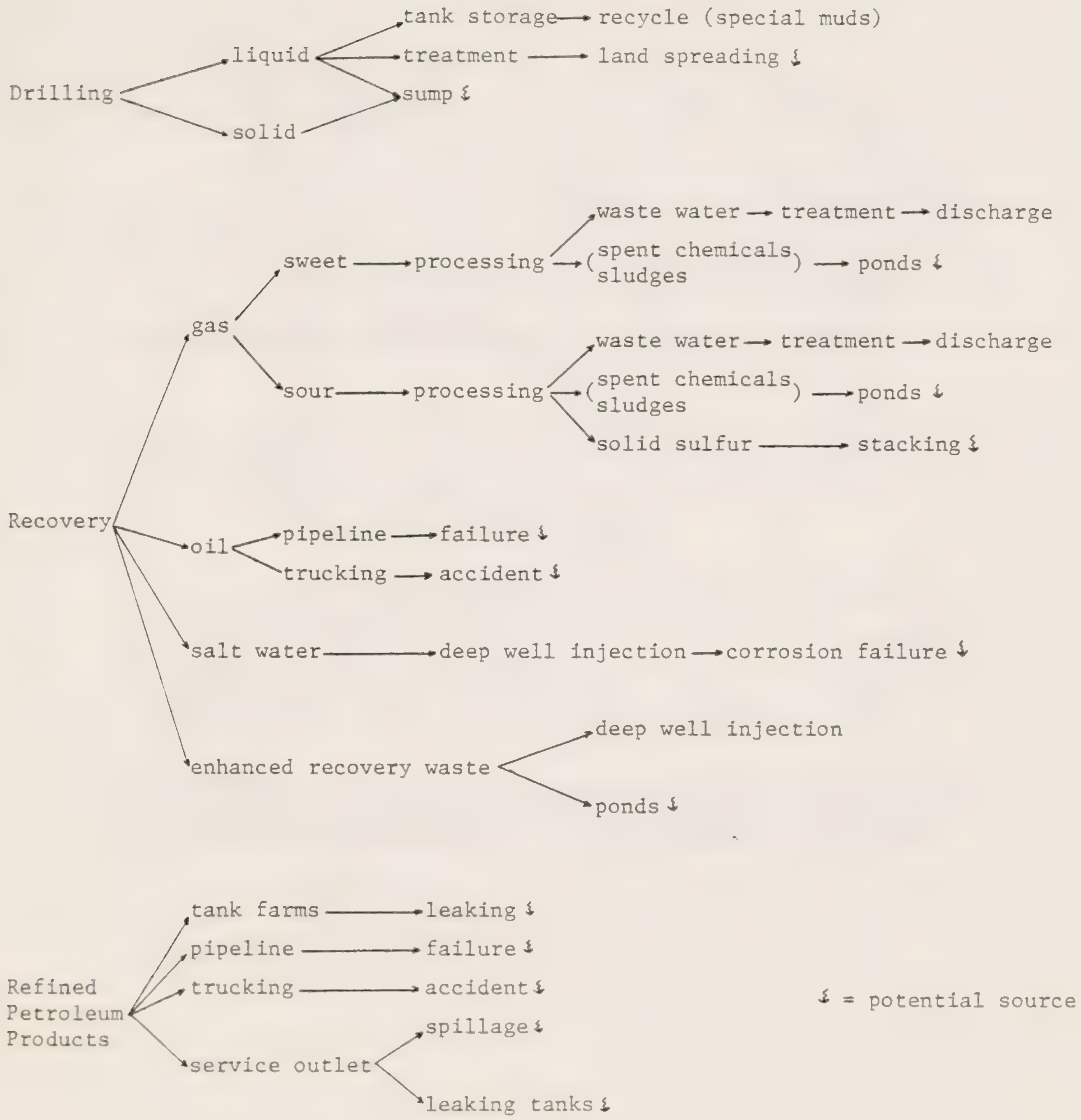


Figure 15. Disposal practices and groundwater contamination (cont.).

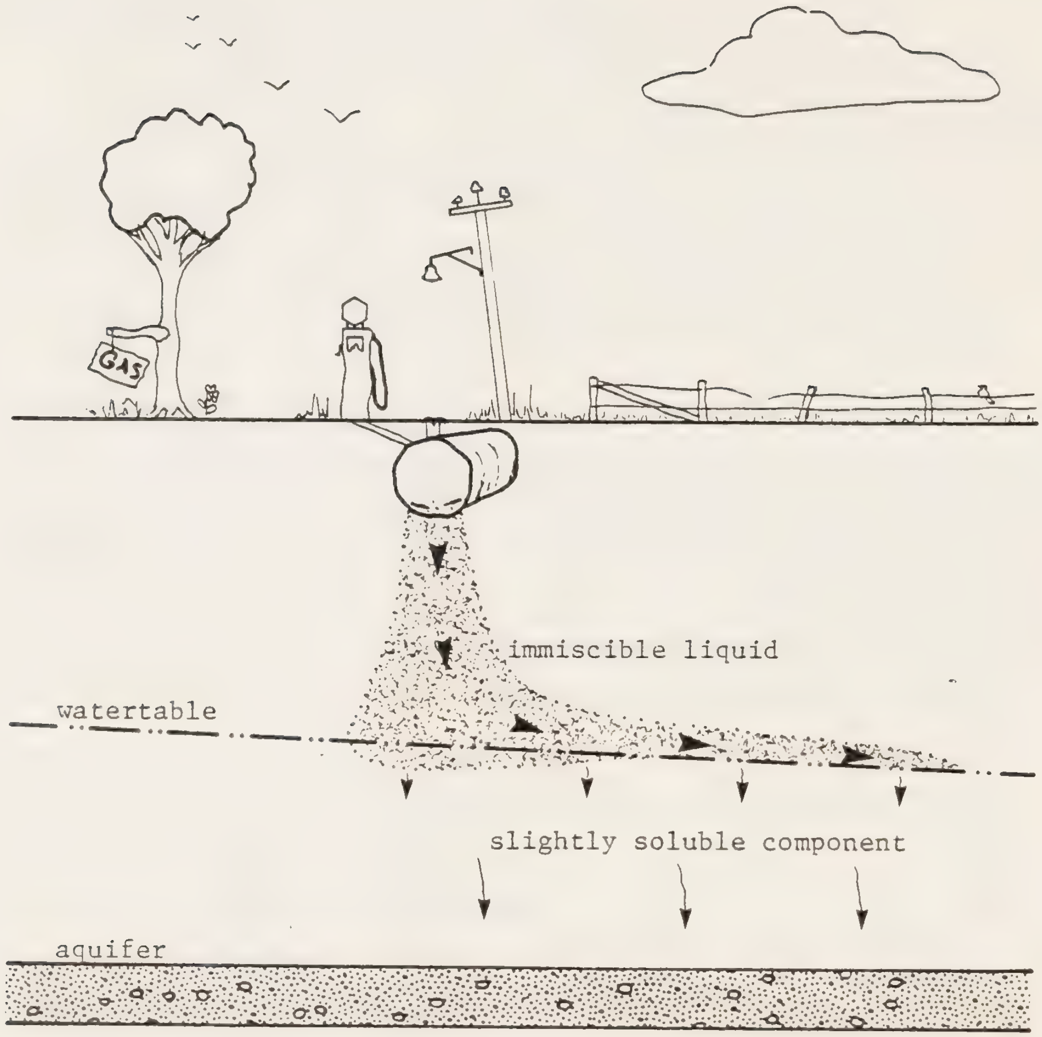


Figure 16. Distribution of immiscible contaminants in shallow subsurface.

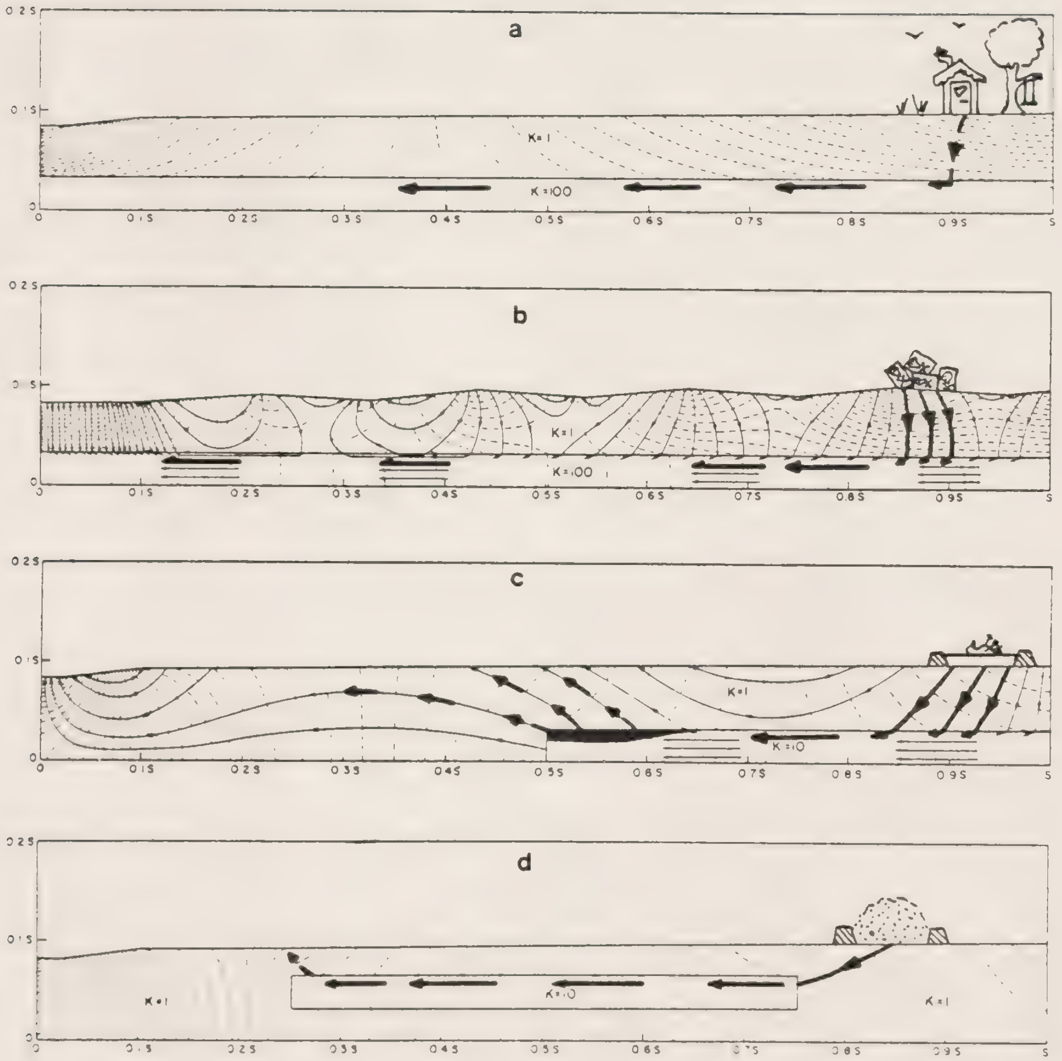


Figure 17. Flow of contaminants in the subsurface.

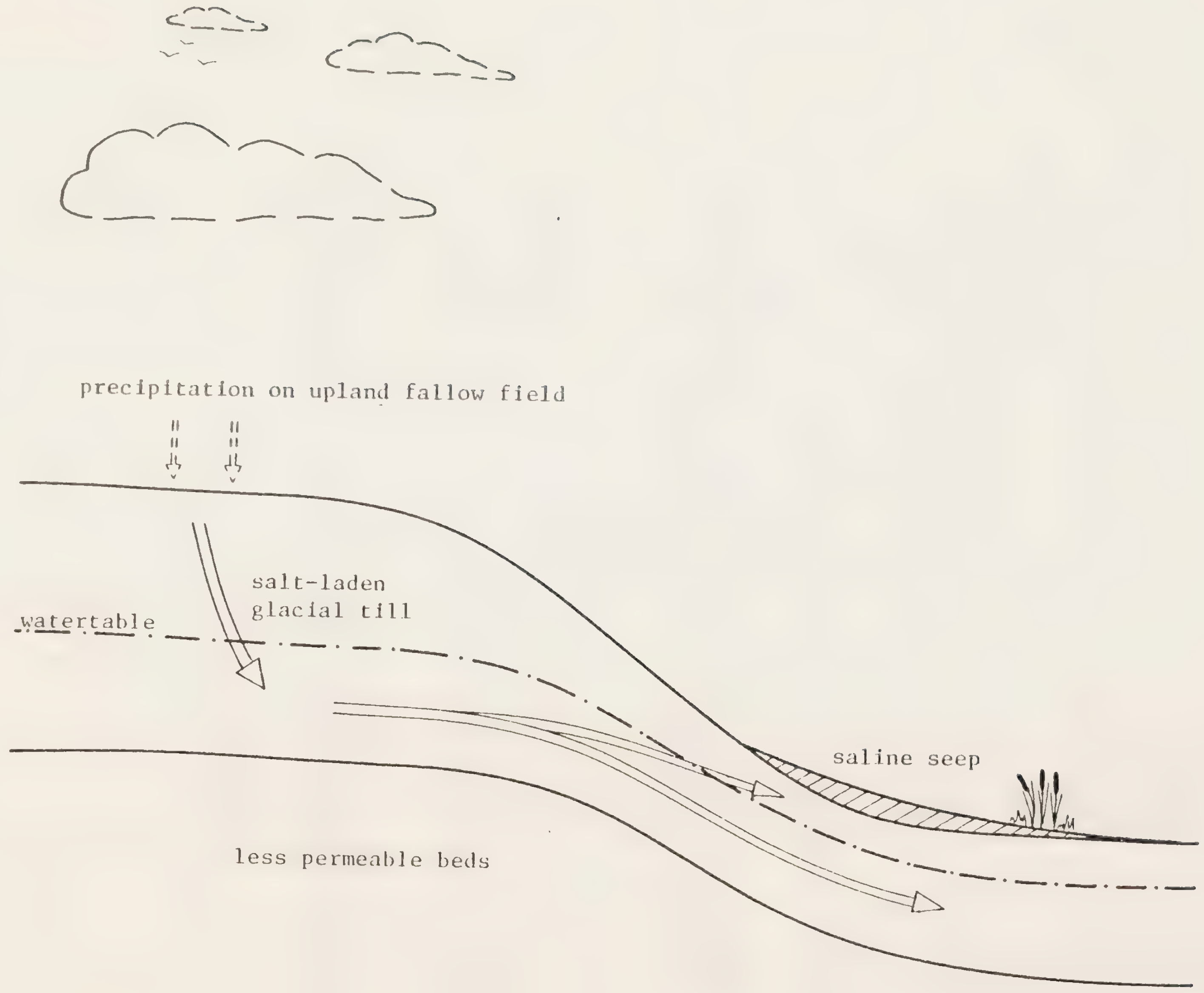


Figure 18. Conceptual diagram of saline seep formation (after Van der Pluym et al., 1981).